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U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, Chief

MONTHLY WEATHER REVIEW

VOLUME 47, No. 3

MARCH, 1919

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

INTRODUCTION.

The MONTHLY WEATHER REVIEW contains (1) meteorological and seismological contributions and bibliography; (2) an interpretative summary and charts of the weather of the month in the United States and adjacent oceans; and (3) climatological and seismological tables dealing with the weather and earthquakes of the month.

The contributions are principally as follows: (*a*) results of observational or research work in meteorology carried on in the United States or other parts of the world, in the Weather Bureau, at universities, at research institutes, or by individuals; and (*b*) abstracts or reviews of important meteorological papers and books. In each issue of the REVIEW such contributions and abstracts are grouped by subjects, roughly, in the following order: General works, observations and reductions, physical properties of the atmosphere, temperature, pressure, wind, moisture, weather, applications of meteorology, climatology, and seismology.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but the publication of such contributions is not to be construed as official approval of the views expressed.

The partly annotated bibliography of current publications is prepared in the Weather Bureau Library. Persons or institutions receiving Weather Bureau publications free should send in exchange a copy of anything they may publish bearing upon meteorology, addressed "Library, U. S. Weather Bureau, Washington, D. C.," in order that the monthly list of current works on meteorology and seismology may be as complete as possible. Similar contributions from others will be welcome. Bibliographies of selected subjects are published from time to time in the REVIEW.

The section on the weather of the month contains (1) an interpretative discussion of the weather of North America and adjacent oceans, and some notes on the weather in other parts of the world; (2) details of the weather of the month in the United States; and (3) brief discussions of weather warnings, rivers and floods, and weather and crops. There are illustrative charts. The climatological tables comprise summaries of the weather and excessive precipitation data for about 210 stations in the United States, and summaries of the weather observed at about 30 Canadian stations.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are due especially to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Havana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The seismological tables contain, in a form internationally agreed on, the earthquakes recorded on seismographs in North and Central America. Dispatches on earthquakes felt in all parts of the world are published also.

Since it is important to have as the name of the month appearing on the cover of the REVIEW that of the period covered by the weather discussions and tables rather than that of the month of issue, the REVIEW for a given month does not appear until about the end of the second month following.

Supplements containing kite observations, and others containing monographs are published from time to time.

SOME WEATHER BUREAU PUBLICATIONS.

A few of the more recent Weather Bureau publications are listed below, with their prices. A complete list may be obtained upon application to the *Chief, U. S. Weather Bureau.*

To secure such publications as have a price affixed, one should apply to and make remittances payable to the *Superintendent of Documents, Government Printing Office, Washington, D. C.* Stamps and personal checks are not accepted in payment. Additional charge for postage for foreign addresses.

National Weather and Crop Bulletin, with charts, monthly from October to March, weekly during remainder of the year	25c. a year.
Snow and Ice Bulletin, with charts, weekly during the winter	25c. season.
Climatological data, monthly for 42 separate sections, each section 5c. a copy	50c. a year.
Complete monthly number, 42 sections	35c. each, $4.00 year.
Monthly Weather Review Supplement No. 9. (Periodical events and natural law as guides to agricultural research and practice.)	25c.
Monthly Weather Review Supplements Nos. 10 and 11. (Aerology Nos. 5 and 6), 1917 kite data	25c. each.
Monthly Weather Review Supplements Nos. 12 and 13. (Aerology Nos. 7 and 8), 1918 kite data, etc.	25c. each.
Weather forecasting in the United States	$1.25
The daily weather map, with explanation (text and 4 charts)	5c.
Instructions for cooperative observers, 5th ed. Circulars B and C combined	10c.
Instructions for the installation and operation of Class A evaporation stations. Circular L	10c.
Report of the Chief of the Weather Bureau, 1917–1918 (4° edition)	Free.
Modern methods of protection against lightning. (Farmers' Bull. No. 842)	Free.
Notes on the climate of France and Belgium	Free.
The Weather Bureau. (Descriptive pamphlet)	Free.
Explanation of the weather map (leaflet)	Free.
Serial numbers of Weather Bureau publications	Free.
Papers on meteorology as a subject for study. (Repr. from Dec., 1918, Mo. Wea. Rev.)	10c.

As the surplus of MONTHLY WEATHER REVIEW SUPPLEMENT No. 2 is limited, recipients who do not care to retain their copies will confer a favor by notifying the Chief of Bureau, who will arrange for the return postage.

FIG. 1.—Smoke column producing cloudy condensation over Sister Elsie Peak. (Photograph made from Echo Mountain, 10 miles east of Sister Elsie Peak. The other cumuli, shown in the photograph, did not appear until after the cloud mantle formed.) [Photographed by O. H. Lawrence.]

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MONTHLY WEATHER REVIEW

HERBERT H. KIMBALL, Acting Editor.
CHARLES F. BROOKS, Associate Editor.

VOL. 47, No. 3.
W. B. No. 680.

MARCH, 1919.

CLOSED MAY 3, 1919.
ISSUED JUNE 10, 1919.

CONTRIBUTIONS AND BIBLIOGRAPHY.

CONVECTIONAL CLOUDS INDUCED BY FOREST FIRES.

By FORD ASHMAN CARPENTER, Meteorologist.

[Dated: Weather Bureau, Los Angeles, Calif., Apr. 12, 1918.]

The spectacle of a cloud-crowned smoke column is not an unusual sight in southern California. Notwithstanding alert forest protection, fires in the timber or chaparral are not uncommon during the long rainless summers of this region. The heat during such fires is intense and concentrated owing to the conflagration being limited to a relatively small area. They, therefore, induce strong vertical convection.

During the past five years five examples of local convection resulting from forest fires in southern California have come under the writer's notice. They have many attributes in common, and yet they possess considerable individuality as the photographs of three of them which accompany this article show.

Example No. 1.—This cloud has already been described in the REVIEW as follows:[1]

> On August 23, at 3:48 p. m., a brush fire in the northern foothills sent up a straight column of smoke. When the fire reached its maximum intensity a small but well-developed cumulus cloud was seen to cap the ascending column. When the smoke column disappeared the cloud lasted two or three minutes. It was an interesting instance of cumulus cloud formed by ascending currents. The sky was free from cloud all day except for this solitary cumulus, which had an existence of less than five minutes.

Example No. 2.—One of the fiercest forest fires in this district, but one which covered a relatively small area, occurred on the morning of September 13, 1913. This fire destroyed the forest cover of Sister Elsie Peak (15 miles north of Los Angeles). In the case of this fire the writer was so near it as to be able to note many of its features. The notes made at the time state that a smoke column was observed ascending over the northwestern horizon. This pillar of smoke mounted steadily to a great altitude, and in a short time was capped by a well-defined cumulus cloud (see fig. 1). Up to the hour of the appearance of the smoke column, the sky was free from clouds, the day being unusually hot, the thermometer registering 90° F. as early as 8:30 a. m., and remaining above 90° until 2 p. m. About 10 a. m. the fire-caused cloud mushroomed, and within an hour the western portion of the sky became filled with cumuli extending in uniform thickness to the seacoast beyond. The photograph of the smoke and cloud above Sister Elsie Peak (elevation 5,080 feet above sea level) was made from Echo Mountain, which has an elevation of 3,500 feet above sea level. The very rapid changes in the structure of the column made a focal-plane exposure necessary. The exposure was about 0.001 second at 10 a. m. The most striking feature of the cloud was the well-defined mantle (scarf cloud [2]) which formed after the cloud mushroomed. This marked the dividing line between the smoke and the ensuing cloudy condensation.

Example No. 3.—Not all forest-fire clouds last as long as the one on Sister Elsie Peak; more frequently they have a very short existence, as, for example, the cumulus cloud which made its appearance in the eastern portion of southern California on August 5, 1915. A member of the Forest Service, on duty in that locality, thus describes it:[3]

> During a brush fire August 5, 1915, a cumulus cloud developed at the head of a smoke cloud which appeared at 3:05 p. m. and lasted 20 minutes. It reappeared at 4:55 p. m. and lasted 12 minutes. The cloud was a typical cumulus and formed close to 1,000 feet above the fire area.

Example No. 4.—Another well-developed cumulus cloud was formed during the forest fire of September 3 1917. This with a scarf cloud at its apex is shown in figure 2. The secondary (scarf) cloud disappeared within 30 minutes, as it is not shown in a photograph made about half an hour after the first picture. This second picture (fig. 3) shows the maximum mushroom phase. Further observation of the progress of the terminating cloud showed that it did not spread out as in previous instances of like formation.

The appearance of this cloud, and its phases, were described by Mr. T. R. Woodbridge, in a letter to the writer, dated Upland, Cal., September 29, 1917, as follows:

> I am sending you a photograph that only partially illustrates a very beautiful phenomenon we had near us * * * (Sept. 3, 1917) during a forest fire east of Cucamonga Canyon. It was a breathless day and even the almost sure sea breeze failed to show up until after 3 o'clock, so the black smoke of the fire went up in the air without a bend in any direction. About noon I saw foaming out from the top of the black smoke a cottony mass of purest white. This appeared first from the center of the black part and boiled from the center outward, gradually spreading toward the outside edges of the black part. The line of demarcation was very sharp and was not broken till about 3:30 p. m. when the sea breeze came up. I was downtown and made a swift run to my home to get my camera into action, but in the short time that this took the appearance had changed to that shown by the photograph [see fig. 2]. It was a magnificently beautiful sight, and the whole community for miles around admired it. You can see the line clearly in the photograph, but the black is much lighter-appearing than it actually was. I regret that I have not a photograph taken earlier, as the black smoke had as regular a pattern as a tall vase, and the pure white cloud was something like a mass of white dahlias or chrysanthemums adorning it.

This description was supplemented by the two photographs (figs. 2 and 3), also a memorandum of tempera-

[1] MONTHLY WEATHER REVIEW, 1912, 40: 1258.

[2] See MONTHLY WEATHER REVIEW, 1917, 45: 361–363.

[3] E. W. Munns, MONTHLY WEATHER REVIEW, 1915, 43: 445.

ture and relative humidity data from privately owned instruments located within a few miles of the fire. From these record sheets a temperature of 84° F. and a dew point of 49° F. were deduced.

Example No. 5.—On December 31, 1917, another observation of cloud formation by a forest fire was made. In a photograph (fig. 4) made from the cooperative storm-warning display station of the Bureau on the shores of Santa Monica Bay, may be seen a cloud from a forest fire originating in the near-by Malibu Canyon. The tall column of smoke was carried horizontally northwestward under the influence of the light off-shore breeze. At an altitude of about 5,000 feet, condensation occurred over the upper surfaces of the smoke.

NOTE.

Some 20 years ago while I was stationed in Minneapolis a large lumber mill was destroyed by fire. The heat was intense and at an altitude of about 1,000 or 1,500 feet, I should judge, a cumulus cloud formed almost directly over the center of the fire. As I recollect, the general movement of the wind on that day was very slight, but the surface winds were quite fresh, blowing in toward the fire on all sides. This I know, because I went completely around the fire for the purpose of ascertaining if such was the case. . . .

The movement of the surface winds on all sides of the fire, in my opinion, is an important factor to be considered, especially in the case of very large fires such as have occurred in the North Pacific States, as well as in Minnesota, Michigan, and Canada. In looking over a Signal Service publication on the forest fires in Michigan, published many years ago, it was noted that the wind force close to the fire was reported to be very strong,[1] whereas the barometric gradients at that time indicated only light winds. I sometimes think that the winds engendered by fires of this character have a tendency to increase the area burned over, as well as the intensity of the fire, by thus supplying abundant oxygen to the burning pile. Of course, if the winds blew inward with equal force on all sides this would not occur, as after the inflammable materials were all consumed that would end the combustion; but if the pressure were greater on one side than on another, then the mass would progress and continue burning furiously so long as there was anything to burn.—*E. A. Beals, Section Director.*[2]

NOTES ON A CUMULUS CLOUD FORMED OVER A FIRE.

C. A. REICHELT, Assistant Observer.

[Dated: Weather Bureau, Honolulu, Hawaii, Dec. 10, 1918.]

An interesting form of the various cumulus clouds which occur almost daily in Hawaii is the small clouds that occasionally appear over the fires of the burning sugar-cane fields. These clouds have been seen near Honolulu several times and close observations were made of a typical specimen on September 27, 1918.

This cloud was observed from a train which passed around the fire and was about 2 miles distant from it. Observations and photographs were made at the stations where the train stopped and the time determined from the train schedule. The fire forming the cloud was from a cane field consisting of 35 acres and located on a narrow peninsula in Pearl Harbor, Oahu, and was about midway between the United States Weather Bureau at Honolulu and the United States Magnetic Observatory at Sisal, Oahu, and about 8 miles distant from each.

The fire began at 4:40 p. m. and a large column of smoke was immediately formed with a slight flattening at the top at a height of about 700 feet. As the fire made headway the smoke became more dense and kept rising and spreading out. The first roll of cumulus developed at the top of the column in about 10 minutes, and was well-marked by its white color, which contrasted strongly with the bronze black of the smoke. The cumulus rolls continued to form swiftly and at 4:57 p. m. (see fig. 1) when the fire was at its height the cloud had almost reached its final size, although the smoke, which was still very heavy, obscured it considerably. As the fire diminished the column of smoke from the earth gradually became less (see fig. 2), but the cloud continued to rise for a short distance, the base clearing somewhat and small rolls still forming at the apex. At 5:03 p. m., when the fire was practically out, the column of smoke from the earth had almost disappeared and a well-formed cumulus cloud was present. It was last seen at 5:15 p. m., or 20 minutes after it began to form, when the train passed out of the field of view.

An estimate of the height of the cloud and also of its size was formed by taking the altitude of the sun, which was observed through the edge of the cloud, and the horizontal distance of the base from the observer. At two different stations approximately the same results were obtained, which gave for the height of the base of the cloud about 1,500 feet and for the top about 2,500 feet, and for the width at the base about 1,000 feet. A comparison with the height of the 600-foot wireless aerial at the Pearl Harbor Naval Station gave a good check on these figures.

The approximate meteorological conditions under which the cloud was formed can be obtained from an average of the records of the United States Weather Bureau and the United States Magnetic Observatory, both of which are official records. The temperature at the Weather Bureau Office, 8 miles to the east, at 4:30 p. m., or just preceeding the fire, was 79°; at the Magnetic Observatory, 8 miles to the west, it was 84°, giving a mean temperature of 82°. The dew point and the relative humidity at both stations were the same, being 68 and 71 per cent, respectively. The direction of the wind was from the south, with a velocity of 8 miles per hour at Honolulu.*

As previously mentioned, these clouds have been observed frequently at Honolulu and they have been seen at all seasons of the year. They are usually formed in the early morning or late afternoon hours and have never been observed forming in the middle of the day. They are best formed under conditions of calm or very light winds, occur over fires of all sizes, and have been known to form over large smokestacks on very still days. They are apparently true cumulus and have the same color, shape, and appearance as other cumulus clouds in Hawaii. Also they do not dissipate rapidly as would be the case with smoke clouds. In the present instance the cloud was only seen for a relatively short time, but in June, 1917, a cloud of much greater size, formed at 8 a. m., was still visible two hours later. No instances have ever been recorded in these islands of these clouds producing precipitation.

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[1] The same was decidedly the case in the Minnesota fires of mid-October, 1918, as mentioned in the MONTHLY WEATHER REVIEW, November, 1918, 46: 506-509, and as described in detail by H. W. Richardson in the Geographical Review, April, 1919, 7: 220-232, 5 figs.—EDITOR.

[2] See also "Meteorological observations during the burning of the plant of the Standard Oil Company at Bayonne, N. J., July 5, 6, and 7, 1900," by W. H. Mitchell (Mo. Wea. Rev., 1900, 28: 325-326.)—EDITOR.

* See discussion on p. 149 of this issue of the REVIEW.

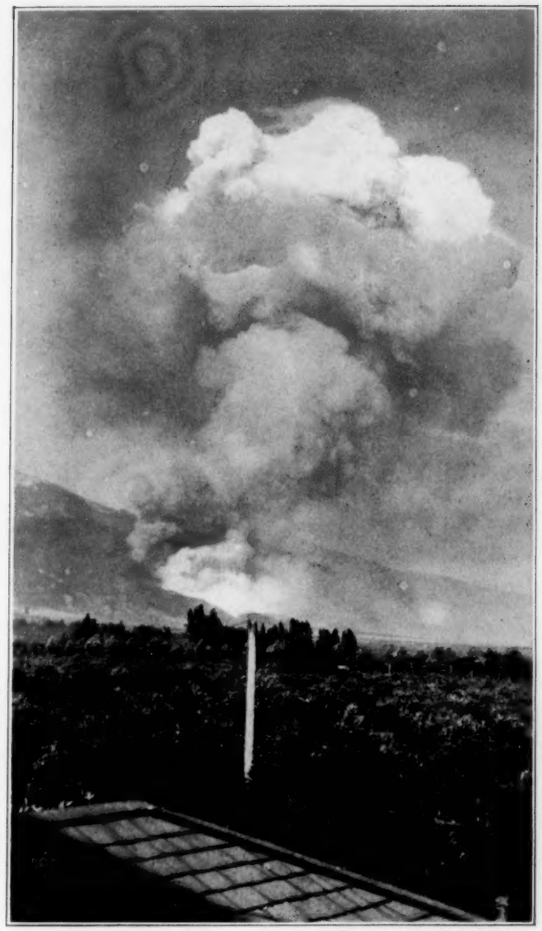

FIG. 2.—Cloud-capped smoke column above Cucumonga Canyon, Calif. The smoke from a chapparal fire along the base of the Sierra Madre Mountains in southern California which terminated in a cumulo-nimbus cloud. Scarf clouds may be seen at the apex of the cloud mass. [Photographed by T. R. Trowbridge.]

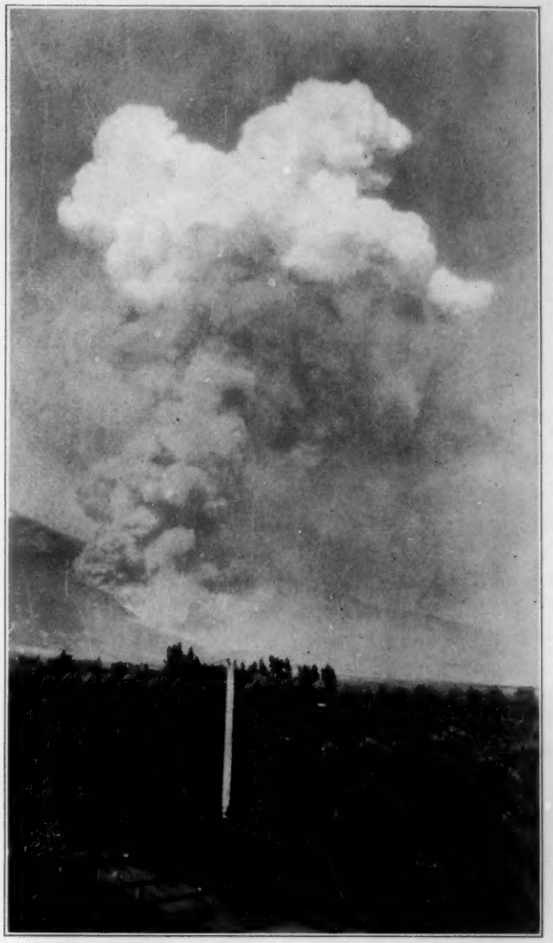

FIG. 3.—Later photograph of cloud-capped smoke column in Cucumonga Canyon. This second photograph was made about 30 minutes after the previous one was taken and shows the disappearance of the "false cirrus" cloud. This photograph represents the maximum mushroom phase, as further observation of the progress of the terminating cloud showed it did not spread out as in previous instances of like formation. [Photographed by T. R. Trowbridge.]

FIG. 4.—Smoke column in Malibu Canyon, Santa Monica Mountains. This photograph was made from the Weather Bureau storm-warning display station on the shores of Santa Monica Bay, and shows a forest fire in the Malibu Canyon. The tall column of smoke was carried horizontally northwestward under the influence of the light offshore breeze. At an altitude of about 5,000 feet condensation occurred over the upper surfaces of the smoke. [Photographed by A. Deraga.]

[To face p. 144.]

FIG. 1.—4:57 p. m., cumulus cloud formed, but considerable smoke still present.

FIG. 2.—5 p. m., cumulus well formed, fire dying out.

RAIN FROM CUMULUS CLOUDS OVER FIRES.

[Extracts from Fourth Meteorological Report of Prof. James P. Espy, 34th Cong., 3d Sess., Senate Ex. Doc. No. 65, 1857, pp. 29-36.]

The observation of cumulus clouds over fires, even over factory chimneys on very damp days, is by no means rare; and so, a general review of all published observations of such clouds does not seem called for. It may be of interest, however, to quote from accounts of cloud developments which were strong enough to precipitate showers.—EDIT.

FALLOW FIRE AND SHOWER AT COWDERSPORT, PA.

[Letter to James P. Espy.]

"COWDERSPORT, PA., *July 29, 1844.*

"* * * On Saturday, the 13th of July [1844], about 1 o'clock, a fallow, containing about 6 acres, was fired. At the time the fire was set the day was calm and warm, and would be considered clear. There were some flying clouds, with slight appearances of rain to the north, but none in the neighborhood. The fire spead rapidly, and burned with great violence. In a short time a white cloud was seen to form over the black smoke which rose from the fire with great velocity, nearly perpendicular. The white cloud rolled outwards above, especially toward the north and south, and probably still more toward the east, as the wind was gentle in that direction, and as the rain which fell from it increased as it proceeded east, as far as heard from. It did not swell out very far to the west. In less than an hour from the commencement of the burning, very large drops of rain were seen by the inhabitants of Cowdersport descending from the cloud, glistening in the sun like diamonds. It rained but little in Cowdersport, which is about 100 rods west of the fire, and none at all one-half a mile west of the village. * * * Mr. Lyman lives 2 miles east of Cowdersport, and he found that the quantity of rain which had fallen constantly increased as he advanced. When he got home he found the ground quite wet. Previous to the rain it was quite dry and parched, suffering much for want of rain. Samuel Taggart lives 6 miles east of Cowdersport, and at his place the shower was very violent, with unusually large drops of rain. The shower at Mr. Taggart's did not last, probably, more than 30 minutes, but it rained an unusual quantity for the time.

"Some of our citizens watched the whole formation of the cloud, and its gradual recession toward east after the rain; and we have understood from credible authority that it rained hard and much longer the same afternoon many miles to the east. We are unanimously of the opinion that *this rain was produced by the burning of the fallow;* and we think it due to your zeal in the cause of science to make this communication to you. * * *

"JOHN S. MANN, *Attorney at Law.*
"CHARLES LYMAN.
"W. C. BUTTERWORTH, *Attorney at Law.*
"SAMUEL TAGGART.
"JOHN B. PRADT, *Episcopal Clergyman.*
"DAVID T. HALL."

"JULY 28, 1844.

"I live about 22 miles east of Cowdersport, and about 2 o'clock on Saturday, the 13th of July, I left home on a beautiful clear day, but I had traveled only about 3 miles when a very heavy shower came on, the drops being uncommonly large, glittering in the sun much of the time. The cloud came up from the west, and had not covered the whole sky when the rain came on; indeed, it did not cover the whole sky at any time, though the rain lasted from half to three-quarters of an hour. This was the first rain we had for a considerable time, and it was very much needed.

"E. JOHNSTON, *Justice of the Peace.*"

"POTTER COUNTY, PA.

"Understanding that you wish to know whether it rained here on Saturday, the 13th of July, 1844, I have to inform you that about 3 o'clock there was a very hard shower about 6 miles east of this place, 28 miles east of Cowdersport, where I was at the time, and I found when I returned home that it had both rained and hailed hard the same afternoon at my house, 22 miles east of Cowdersport. * * *

"FRANCIS L. METZGAR."

PRAIRIE FIRE IN INDIANA.

Dr. W. Hembel Salter, of Pulaski County, Ind., gives me an account of a rain which was produced by the burning [over] of a prairie, 7 or 8 miles northeast of his residence, on the 6th day of August, 1843. He says:

"WINNIMAC, IND., *August 28, 1843.*

"The day had been exceedingly sultry and warm; the thermometer stood at 88°; several clouds were seen floating at the time at a great height, but there was *no appearance of rain.* At 15 minutes before 3 o'clock a gentle breeze sprang up from the southwest, blowing directly toward the fire, which at 3 o'clock had increased to a perfect gale. The dark volumes of smoke and flame at this time had ascended to a great height, when, after reaching an immense height, it was observed, by the direction which the dark mass assumed, that there was a counter current of the atmosphere above, toward the west by southwest. I was now an eyewitness to the formation of the clouds. At first the cloud was insulated; I could see all round it, and I do not believe any other clouds were seen at that time within 50 miles of this place. Nothing could exceed at this time the magnificent appearance of the sky.

"The clouds kept forming until, seemingly unable to support their weight, they rolled over each other until they appeared to have enveloped the whole heavens in gloom, when, falling into the lower current, they were conveyed toward the northeast, where, I think, much rain must have fallen. * * *

"W. HEMBEL SALTER, M. D."

FLORIDA SHOWERS FROM BURNING SAW-GRASS PONDS.

"DEAR SIR: Your request for a relation of my experiments upon your theory of storms is flattering. I answer it with pleasure. They were at first accidental, and afterwards intentional. I will describe both.

"In 1845 I was engaged in the public survey on the Atlantic coast of Florida. Some time in April (the time of the dry season there, which lasts up to June) I was running a township line between latitudes 26° and 27°, about 5 miles from the sea. The weather was oppressively warm that day; there was not air enough stirring to move an aspen leaf. We found our line must pass through a saw-grass pond containing about 500 acres.

In ponds of this description the green grass at the top shoots up from 5 to 6 feet in height, and when the region has not been for some years swept clear by fires, the dead and dry growths of preceding seasons accumulate under the latest growth, and are often found there from 2 to 4 feet in depth. They are exceedingly inflammable. When lighted in dry weather, they burn with frightful rapidity and violence. Whenever, in our explorations, we came upon a place of this description, we could only pass our line by cutting away the lofty fresh grass, and wading (or rather wallowing) through the mud and under rubbish. On the day in question we determined, as it was so hot, that, to save ourselves trouble, we would burn our way through. * * * [After lighting from both sides,] in a very few minutes an awful blaze swept over the entire surface, which we had marked out for our purpose. We then crossed our line. Ere we had proceeded over 40 chains a delightful breeze sprang up and cooled the atmosphere, and presently a refreshing shower sparkled in the bright rays of the sun. All this excited no further observation than that it had not rained before there for a long time. * * *

"Our work went on for some days without a repetition of our short cut at pioneering. * * * At length, however, the pleasant breezes ceased, which had made the weather for a while endurable, and the still air and intense heat returned, and with them constant murmurs from the men, especially the negroes, whose duty it was to cut lines and mark trees. We were now on the confines of a saw-grass pond, and a much more formidable one than any we had yet encountered. Being surrounded by a cypress swamp, we concluded that it had never yet been burned. My assistant, Capt. Alexander Mackay, mentioned his having in our late conflagration observed the formation of a cloud at the apex of the smoke. He added that it had frequently since brought to his mind some account which he had read of Prof. Espy's theory. He suggested that there could not be a better opportunity than this to put the theory to the test, and being fond of a joke, he said he would like to astonish the superstitious negroes, and to make them believe that he could call together the clouds and bring down rain. So we determined to make the experiment.

"When our party were all gathered at the halting place complaints of the extreme heat went round, and all unanimously agreed that a more confined and oppressive day had never been known to them. To these complaints the usual wishes for a 'little breath of air' and a 'few drops of rain' succeeded. 'Cut through this pond,' exclaimed the captain, 'and I'll bring you more than a few drops of rain; I'll give you a plentiful shower, and a breeze, too, that shall wake you up. Come, boys, cut away, and when you've done you shall wash off the dust in a cold bath from the skies!' They stared up and around; not a cloud as large as a man's head was to be seen, and they looked back at the captain with a good-natured grin of incredulity. 'Ho, ho! ha, ha! captain make cloud out o' nuffin; he, he! captain bring water all dis way from de sea! Ho, ho! ha, ha! he, he!' Whereupon the captain affected to be very indignant. To hasten his victory, I ordered the grass to be set on fire. The flames soared forthwith above the tallest trees; a dense volume of smoke mounted upward spirally; the grass soon disappeared; we crossed over. As the smoky column broke and the cloud began to form, the captain traced a large circle in the sand around him, and placed himself in its center, making fantastic figures and forming cabalistic phrases out of broken French; still was the cloud unnoticed. All eyes were riveted upon the captain, who stood gazing at the earth, and shaping outlines of devils there. At this juncture came a roll of distant thunder; every glance instantly turned upward; a cloud was spreading there; the thunders increased; the lightnings flashed more vividly; the knees of the negroes shook together with alarm; already was the rain descending, and in torrents, though the clear sky could be seen in all directions under the cloud. The captain, meanwhile, maintained his mystical attitude, and continued his wild and extraordinary evolutions. Some of the whites who were in the secret of the hoax fell on their knees, and were imitated by the negroes, whose fears augmenting as the storm grew fiercer, with clasped hands fastened upon the captain a stare of awe and deprecation. In short, the scene presented a more complete triumph of philosophy over ignorance than I could have supposed it possible to have produced anywhere in the nineteenth century, and most especially anywhere in our enlightened Republic.

"We often fired the saw-grass marshes afterwards; and whenever there was no wind stirring we were sure to get a shower; and I say with perfect confidence that we never had a shower in April or May at any other time. Sometimes when there was a breeze, it would carry the smoke toward the horizon, where there would seem to be a fall of rain.

"GEORGE MACKAY.

"P. S.—I have lately been informed by A. H. Jones, United States deputy surveyor, that he has performed a great many experiments in Florida of a similar nature, with like success; and that for some years several farmers, who became acquainted with these experiments, have been in the habit of setting fire to the dry grass at the time they plant their corn to produce rain; and that they generally succeed, though (this being in the dry season) it is known that no rain would otherwise occur.—G. M."

FOREST FIRE THAT QUENCHED ITSELF.

"July 14, 1846.

* * * *

"[After an almost complete dry spell of five weeks on Isle Royale, Lake Superior, on the 11th of July, the woods on the island, whether accidentally or by design, took fire.]

"The rocks in this country are covered with a heavy growth of moss, and the trees, which are mostly spruce, Canada balsam, birch, white cedar, and white and yellow pine, are also hung with moss similar to that which is found in the South. It collects upon the underbrush, which is so thick that a man can only with great difficulty make his way through it.

"The fire, during the night of the 11th, spread to a slight degree, but on the 12th the wind rose and the flames raged like a whirlwind, seeming to leap from tree to tree like threads of electric fluid and darting onward as if desirous to consume every living thing. The moss, the branches of the balsam trees, the pitch concealed in the rough bark, and that still more ignitable matter, the outside bark of the birch, all seemed to woo the fiery element to the fullest display of its resistless fury.

"During the burning on the 12th there appeared clouds around and about the fire, which swept away to the east of the fire. In the evening the wind ceased, and all was clear as before, and the fire seemed smoldering as if it were in repose after the destruction of the day. On the morning of the 13th the wind arose with more than usual violence about 10 o'clock. The fire had spread a mile or two to the west, and had become one general conflagration for the area of about 5 miles square, where the

clouds around and about, and to the east of the fire, again made their appearance, while in every other quarter it was clear. Now, said I, to one of the company, 'If Espy's theory is worth anything, we should have a shower of rain.'

"The clouds now began to grow more massive, and repeatedly changed color, giving decided evidence of an approaching storm. In a few moments more the rain began to fall, first in large crystal drops in exact imitation of an evening sunshine shower, and then a heavy dash of rain descended, which wet us to the skin, and continued until the fire was extinguished.

"For weeks before there had not been a cloud to be seen, and at the time the rain was descending there were no clouds to be seen, except on the island in the immediate vicinity of the fire. Every place else was enveloped in clear, bright sunshine. The evidence that the rain was caused by the fire was unmistakable, for with the fire came the clouds, with the clouds, the rain; and when the fire was quenched by the rain, all was again brightness and sunshine.

"ABEL SHAWK."

FALLOW FIRE AND SHOWER IN NEW HAMPSHIRE.

"In July, 1856, I had occasion to cross this ridge [west of Keene, N. H.] and to pause on its summit to give a little rest to jaded animals. The weather was excessively hot. Not a cloud was to be seen, nor was there a breath of wind stirring. Looking to the southeast at a distance of some 5 or 6 miles, I saw a fire just kindled in a fallow of some acres extent. * * * Up went the column straight as an arrow, and anon it began to expand at the top and assume the appearance of cloud. This cloud, with its base stationary, expanded upward, and swelled as if a huge engine was below with its valve open for the escape of steam. The thin white cap appeared; the color changed, and soon the rain began to descend.

"It remained stationary for a few minutes, looming up higher and widening on either side a few minutes, and then sailed off in an eastern direction, pouring down torrents of rain in its pathway. I do not know the exact time occupied in this process, but I do not think more than half an hour elapsed between the kindling of the fire and the time the rain commenced falling. All this time at my point of observation the sun was shining brightly, and, besides that one over the fire, there was no cloud to be seen."

"J. D. WILLIAMSON,
"*Pastor of the First Universalist Church.*
"OCTOBER 30, 1856."

THUNDERSHOWERS FROM GRASS FIRES IN PARAGUAY.

"M. Dobrezhoffer, in his account of the Abiphones of Paraguay, volume 3, page 150, says: 'I, myself, have seen clouds and lightning produced from the smoke over the tall grass and bulrushes, as it is flying off like a whirlwind; so that the Indians are not to blame for setting fire to the plains in order to produce rain, they having learned that the thicker smoke turns into clouds, which pour forth water.'

"The bad philosophy of supposing that the smoke turned into cloud does not invalidate the evidence here furnished, that rain was produced by the fire."[1]

[1] Naegler (Das Wetter, Aug.-Sept., 1917, p. 179) reports the formation of a great cumulus over a fire on a nearly calm day at Kobilnik, Russia, June 21, 1917. About 4 km. from the fire large raindrops fell for 10 or 15 minutes. He mentions also the common formation of great cumulus clouds over the savanna fires during the dry season in tropical Africa.—EDIT.

VOLCANO RAINS.[2]

"Baron Humboldt gives, as an instance of what he calls the *mysterious* connection between volcanoes and rain, the fact that when a volcano breaks out in South America in the dry season, it turns it, while the volcano is in blast, into a rainy season.

"In his Views of Nature, page 366, speaking of Vesuvius in the last great eruption, he says: 'The long drought which had parched and desolated the fields before the eruption was succeeded toward the termination of the phenomenon by a continued and violent rain, occasioned by the *volcanic* storm which we have just described. A similar phenomenon characterizes the termination of an eruption in all zones of the earth. As the cone of cinders is usually wrapped in clouds at this period, and as the rain is poured forth with more violence near this portion of the volcano, streams of mud are generally observed to descend from the sides in all directions.' "

HEIGHTS OF CUMULUS CLOUDS FORMING OVER FIRES.

By S. P. FERGUSSON and C. F. BROOKS, Meteorologists.

[Dated: Weather Bureau, Washington, D. C., May 3, 1919.]

Apparently, very few measurements have been made of the height or movement of cumulus clouds over fires. The writers know of but six instances of the kind, and since they are of unusual interest to students it seems desirable to present a brief account of the formation and heights of these clouds.

The first example is a measurement made by A. E. Sweetland and S. P. Fergusson of two small cumulus clouds forming over a fire which destroyed the Bay State Iron Works, in South Boston, June 30, 1899.[1] On this date the weather was fair, the sky nearly cloudless in the afternoon, and the surface wind very light and from a westerly direction. The fire began shortly before 8 p. m. and the smoke-cloud was not of unusual size, but rose vertically to a considerable height (800 to 1,000 meters), encountering at this height a northwesterly wind, which swept it nearly horizontally over Boston Harbor. The smoke reached its greatest height about 8:05 p. m. At 8:03 p. m. a small white cloud began to form at the apex of the smoke, which at this time was nearly over Long Island, in the harbor. This cloud increased rapidly in height, assuming the form of a true cumulus, and reached its greatest dimensions at 8:05 p. m. It was about 3° in height and length, the highest or thickest end being toward the north. Between 8:05 and 8:07 p. m. another, smaller cloud formed at the eastern edge of a rift in the smoke considerably lower than the first and about 5° farther north. Mr. Sweetland, at Winthrop, 8 kilometers northeast of the fire, estimated the altitude of the higher cloud to be 15°, while a measurement with nephoscope by Mr. Fergusson at Blue Hill Observatory, 16 kilometers south of the fire, gave 10° as its altitude as seen from the observatory. These measurements show that the higher of the two clouds was at least 2,500 meters, while that of the lower was about 2,000 meters, above sea level.

The smoke began to diminish in quantity at 8:07 p. m. and separated from the clouds, which became flatter and more elongated. At 8:11 they separated from the smoke by a space several degrees wide, and after this time they slowly evaporated.

[1] Described, with sketch, in Science, July 21, 1899. p. 86.
[2] Cf. Hann's Lehrbuch d. Meteorologie, 3d ed., 1915, p. 692.—EDIT.

During the conditions prevailing on June 30—relatively dry air and clear sky—the level at which cumulus will form is higher than usual, but at or after sunset, when the fire occurred, the level where condensation in air rising from the surface would occur must have been considerably lower. At the Boston office of the Weather Bureau at 8 p. m. the temperature of the air was 19.7° C. and the dewpoint 6.7° C. Under forced ascent and adiabatic cooling, air with this temperature and dewpoint would become cloudy at about 1,700 meters above sea level [$H_m = (t_a - t_{dp})/.0077$]. Therefore, it appears that the fire caused clouds to form some 300 to 800 meters higher than might otherwise have been the case.

The next instance occurred on April 12, 1908, during the great conflagration in Chelsea, Mass., when more than 2 square miles of city blocks were consumed. The fire began about 11 a. m. and the clouds formed between 2 and 3 p. m., when the column of heated air was at its maximum extent.

The sky was cloudless, the temperature in the afternoon was 7°C. (or below normal), the relative humidity was very low—14 per cent—and a strong gale blew from the north-northwest. The column of smoke was of immense size, and at its highest point, situated over Boston Harbor some 19 kilometers from Chelsea there formed a succession of flat, white cumulus clouds, which after drifting farther to leeward, slowly dissolved as they sank into a warmer stratum, because no longer supported by the rising column of heated air.

Approximate angular measurements, made at Blue Hill Observatory by Mr. L. A. Wells and in Boston by Prof. A. L. Rotch, gave the minimum height of these clouds between 4 and 5 miles (average, 7,200 meters). Their relative velocity, compared with the surface wind, also indicated that they were much higher than the ordinary cumuli which float at the level of about a mile (1,609 meters). Mr. Fergusson discussed these observations with Prof. Rotch at the time, and although the altitudes were estimated, both observers were accustomed to making such estimates; and while almost all estimates of altitudes are too high, it does not seem likely that the height given is more than 1,000 meters too great. During the conditions prevailing on the afternoon of April 12, 1908, the potential height of the bases of cumulus clouds, computed from the depression of the dewpoint, was about 3,500 meters. Hence, we have in this a good example of a cloud forming artificially at nearly twice the height it should form under natural conditions.

This cloud was described by Prof. Rotch in Science, May 15, 1908, pages 783–784.

A third example occurred on October 21, 1908, when the column of heated air was not of itself sufficient to form clouds of appreciable size, but caused a rapid increase in dimensions of small fracto-cumuli drifting over the fire. On this occasion a large barn about 2 kilometers east of Blue Hill Observatory was consumed. The contents, chiefly hay and straw, burned with great intensity, the flames rising 30 meters above the building. The fire began at 1:15 p. m. and reached its maximum intensity at about 1:45 p. m. On this date the temperature was below normal and a moist sea breeze of about 7 m./s. was blowing from the northeast. A few small fracto-cumulus clouds were floating in this wind at a height, determined by observations of their shadows, of about 1,000 meters. The observations and sketch (fig. 1) given were made at the time by Mr. Fergusson.

At 1:20 p. m. a few distinct nuclei were observed in the upper surface of the smoke cloud and between this time and 1:50 p. m. the number varied from one or two to more than 10. At 1:35 p. m. a small patch of fracto-cumulus on drifting into the smoke rapidly increased in density, a shell of cloud forming outside the original cloud, and which slowly united with it. At 1:40 p. m. the small cloud was double its original size, after which it diminished, disappearing at 1:55 p. m. The height of this cloud, observed by means of a transit, was about 1,100 meters, or slightly higher than the clouds in the free air at a distance from the fire.

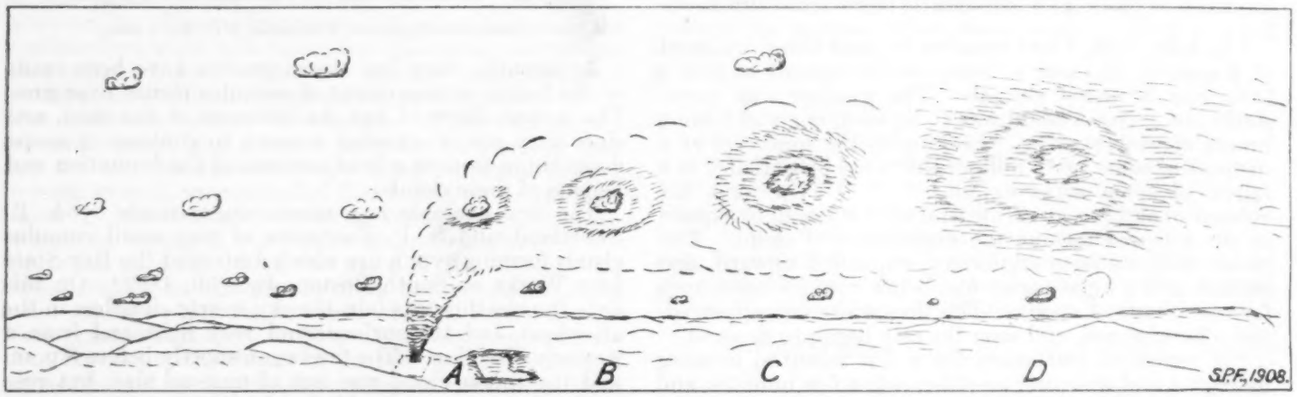

FIG. 1.—Growth of cumulus clouds in heated air over fire, Milton, Mass., Oct. 21, 1908. A, 1:35 p. m.; B, 1:40 p. m.; C, 1:42 p. m.; D, 1:45 p. m.

In figure 1 the successive appearances of the small cloud in the heated air column are indicated by A, B, C, and D.

The fourth example also was obtained at Blue Hill Observatory, by C. F. Brooks on July 22, 1913, when a large cumulus formed over a burning fertilizer factory in Weymouth, 16 kilometers east-northeast of the observatory. The fire began at 3:35 p. m. and the smoke cloud reached its maximum intensity at 3:47 p. m., rising at an apparent angle of 33° to 38°. The cumulus cloud appeared at 4 p. m. and disappeared at 5 p. m. Photographs were made at 4, 4:03, and 4:15 p. m. The following observations were made with a transit:

	Summit of cloud.		Southern edge.
Time	4:25 p. m.	4:35 p. m.	4:35 p. m.
Altitude	5.4°	4.6°	3.1°
Azimuth	250.5°	248.5°	261°
Probable distance of cloud	17 kilometers.	18 kilometers.	18 kilometers.
Height above sea level	1,800 meters.	1,700 meters.	1,200 meters.

Azimuth of fire, 254°; direction and velocity of wind, S. (360°), 7 m./s.

The temperature at Blue Hill was about 25° C. At 8 p. m. it was 18.9°, the dew point 16.7°, and the maximum of the day 28.3° C. Therefore, the height of the potential cumulus base was about 1,000 m. above Blue Hill, or 1,200 m. above sea level. Thus, the fire-formed cloud seems to have been but little, if any, higher than the elevation at which clouds would have formed naturally.

The fifth example was observed at Lindenburg, Germany, on July 29, 1917, by Dr. H. Hergesell, and a description with a photograph was published by him in Das Wetter, August–September, 1917, pages 178–179. On that date a large forest fire occurred and the smoke cloud, mounting to 1,255 meters, became limited, for the most part, by an inversion of temperature (observed by kites at 1,000–1,200 meters). Over the hottest part of the fire, however, the upcurrent was warm enough, with the aid of the latent heat from condensation, to push through this limiting inversion layer and to form a cumulus cloud with an apex rising to 1,800 meters.

The last example is that given by Mr. Reichelt on page 144 of this issue of the REVIEW. The height of the base of the cloud observed was about 1,500 feet and that of the top 2,500 feet (approximately 450 and 750 meters, respectively). From the data as to temperature and humidity given, the height of the potential base of cumulus clouds at that time was 750–850 meters. Thus it seems that the moisture contained in the burning leaves added so much humidity to the air that even at the high temperature of the rising column, condensation took place appreciably lower than would have resulted from fireless convection.

From these examples, it appears that the height at which cumulus clouds will form over fires depends largely on the dryness of the hot air ascending from the fire; and, therefore, that the height of the cloud base is generally greater over burning buildings than the height of the potential base if there were normal convection, but less over burning leaves or other material containing much water.

RESULTS OF OBSERVATIONS OF CLOUDS DURING THE SOLAR ECLIPSE JUNE 8, 1918.

By S. P. FERGUSSON, Meteorologist.

[Dated: Weather Bureau, Washington, D. C., May 3, 1919.]

Observations of the kind, amount, direction (azimuth), relative velocity, and position of clouds were received from 17 stations equipped with nephoscopes and located within or near the zone of 90 per cent totality; also, there are available at these and other stations, notes concerning changes in appearance of clouds, unusual phenomena, etc. At two stations nephoscopes were improvised by the observers, and at a third azimuths were observed by means of a compass.

Observations of azimuth, etc., were made every half hour from noon local standard time until the last regular observation of the day, except during the period beginning an hour before and ending an hour after totality, when they were made every 10 minutes.

Table 1 contains all the data of azimuth and relative velocity of clouds observed continuously during the eclipse, excepting those at stations reporting severe thunderstorms and stations where no change of condition was observed. The data from the latter are referred to in the notes accompanying the table.

In figure 1 the actual observations of azimuth, as made, are plotted with reference to the position of the shadow according to the method employed in the study of the winds and described in the REVIEW for January, 1919, 47: 12–13. The data are given for each 10-minute interval before and after totality.

As in the instance of the wind at the earth's surface, it is to be expected that the direction of motion of the lower clouds, and perhaps, under extremely favorable circumstances, that of the upper clouds, will be affected by the eclipse-shadow. However, since the mean velocity of the wind in which the clouds float is higher than that of the surface wind, the influence of the shadow will be definitely measurable only when the velocities of the upper air are relatively slow or below normal. In the instance of the lower clouds accurate measures of the direction often are difficult to obtain, particularly when the conditions are favorable for local storms and the complex movements, horizontal and vertical, of parts of the same cloud are likely to be confused with the general drift of the air. In one important respect observations of clouds are of greater value than records of wind at the surface; they indicate motions of the free air uninfluenced by local topography (mountains, buildings, etc.).

As stated in the discussion of the winds recorded during the eclipse, the meteorological conditions generally near the shadow-path, were unfavorable for this study because of thunderstorms and other local phenomena, and for this reason many of the records of cloud observations could not be used. One very favorable circumstance was that the velocities of clouds in nearly all instances were unusually low.

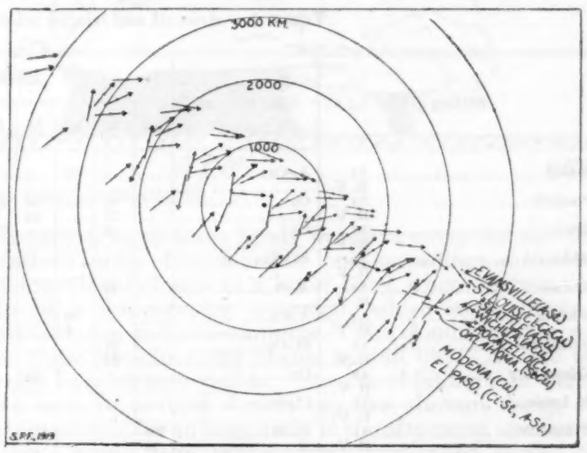

FIG. 1.—Changes in the directions of clouds during the solar eclipse, June 8, 1919.

No data of diurnal variations of the direction and relative velocity of clouds are available for the United States except in New England. Averages of hourly observations at Blue Hill Observatory show that the direction of the upper clouds tends to become more westerly in the early afternoon and return to the original point toward evening. For example, clouds moving from azimuth 130° at 10 a. m. would very probably change to 110° at 1 p. m. and back to 130° by 6 p. m. It is reasonable to suppose that the same kinds of clouds follow the same general law, at least approximately, at stations in other parts of this country; but, in view of the facts that these diurnal periods are small and that unusual conditions prevailed on June 8, it is considered inadvisable to attempt to apply corrections. The average duration of the eclipse at any station was about two hours and the difference

in the time of occurrence of totality, between the Pacific coast and Florida, about three hours, consequently it should be possible, with a large number of observations, to ascertain any measurable influence of the eclipse regardless of diurnal changes in direction or velocity.

Referring to the directions of clouds plotted in figure 1, it is quite apparent that slight changes in the directions of the upper currents are indicated, of which the amplitude was smallest at the cirrus level (9,500 meters), larger at the cirro-cumulus and alto-stratus level (7,500 to 5,000 meters), and largest at the cumulus level, which, under the conditions prevailing on June 8, was higher than usual and probably at least 2,000 meters above sea level. Generally, the changes in the directions of the clouds resemble the changes in the direction of the surface wind indicated in figure 6, published in the REVIEW for January, 1919, **47**:13. At St. Louis and Evansville, where cirro-strati were observed, the eclipse occurred late in the afternoon, and since the influence of the shadow must have been small, it is possible that the slight changes reported are the usual variations to be expected between individual observations; but it is significant that these slight variations of direction are in agreement with the changes observed at other stations.

The observations of relative velocity are somewhat irregular and are insufficient in number for the purpose of determining resultant directions and velocities. To obtain accurate or comparable resultants it is necessary to know the actual height and velocity of the clouds at least approximately; and no trustworthy data are available. The heights of the cumulus and strato-cumulus bases could be computed from observations of the dewpoint, but separate observations of the tops and bases were not made on June 8, and since on that day the vertical extent of these clouds was considerable, resultants computed from existing data would very probably be uncertain. It seems likely that some of the irregularities in the relative velocities may be accounted for by assuming that successive observations were made on parts of clouds differing considerably in height.

The relative velocities of the cumulus and strato-cumulus indicates a tendency toward a minimum near totality; and the data from Pocatello, directly in the eclipse track, and Oklahoma, a little to the south of the track, show several maxima and minima. The alto-stratus observed at El Paso indicates a slight minimum 10 minutes after totality followed by a maximum 35 minutes after totality. The relative velocity of the alto-cumulus at Wichita increased steadily to a maximum near totality and thereafter decreased slowly.

Summary.—The results of observations of clouds during the eclipse of June 8, 1918, indicate that the moon's shadow causes a slight change in the condition of the atmosphere even at considerable heights above the earth's surface.

It is possible that studies of these phenomena may be of importance to meteorology for the reasons that the data are of actual changes of condition of the free atmosphere due to a single cause—the temporary cooling of the air—uninfluenced by errors due to topography (mountains, buildings, etc.), that so often vitiate records obtained at the surface of the earth. The equipment required for an intensive study of eclipses is simple and inexpensive, and if ample time is allowed for preparation it is believed that further effort in this field will be more than justified.

TABLE 1.—*Azimuth and relative velocity of clouds during the solar eclipse, June 8, 1918.*

Station.		Kind of cloud.	Minutes before totality.											Minutes after totality.									
			105	95	85	75	65	55	45	35	25	15	5	5	15	25	30	35	45	55	65	75	85	95
Seattle	Az.	A.-Cu.			62			65	45	55	45	50	50	60	55	40	45	45	40	50				
	R. V.																							
Pocatello	Az.	Cu.		98		94	110	110	70	110	88	78	84	95	80	85	85	78	76	80				
	R. V.			23		15	16	20	15	20	26	20		23	22	28	25	24	18	16				
Reno	Az.	Cu.		10			20	20	10	0	0	0	0	10	10	10	15	15						
	R. V.																							
Modena	Az.	St.-Cu.						206	202	205	197	230	225	223	202	193	205				235			200
	R. V.							3	3	2	2	2	2	2	2	2	2				3			3
El Paso	Az.	A.-St.		49			56	58	56	57	58	58	60	54	56	57	52	50	53			51		
	R. V.			7			9	8	8	9	8	9	8	7	7	6	8	8	7			7		
Wichita	Az.	A.-Cu.			70		53	48	58	58	58	75	65	65	70	66	66	83	83	87		87		
	R. V.				8		12	10	12	12	12	13	14	14	13	12	12	12	12	10		10		
Oklahoma	Az.	St.-Cu.		21			43	41	40	38	19	18	10	8	15	15	18	18						
	R. V.			32			22	18	22	24	18	19	22	24	12	18	18	8						
Kansas City	Az.	Cu.				12	12	12	12	12	12	11	11	11	11	11	11	10	8	8		8		
	R. V.																							
St. Louis	Az.	Ci.-St.					141	126	95	93	95		89	92	96	84		89	94	97				
	R. V.							12	5	7	5		6	8	4	5		4	6	5				
Evansville	Az.	Ci.-St.	108			114					99	100	114	111	109	110								
	R. V.		10			12					15	10(?)	16											

The azimuth (or direction from which the clouds move) is expressed in degrees, beginning with south (0° or 360°) and reading clockwise through west (90°), north (180°), and east (270°) to south. The relative velocity is the distance, in millimeters, traveled in 25 seconds by the cloud image when the eye of the observer is 12 centimeters above the mirror of the nephoscope.

NOTES.

Seattle, Wash.—Azimuths of clouds were obtained by means of a nephoscope devised by Mr. H. W. McKenzie: instrument accurately graduated to 5°.

Portland, Oreg.—At 3:23 p. m. A.-Cu. clouds rapidly grew heavier, and at 3:33 were changing to St.-Cu. At 3:43 strange stratified clouds appeared suddenly in the northwest, long thin lines extending from southwest to northeast. These clouds covered about 0.3 of the sky and were unlike any clouds the observers remember having seen. This unusual cloud disappeared at 3:53 p. m. At 4:03 p. m. St.-Cu. began to change back to A.-Cu. This change may have been apparent and caused by the change in light as the eclipse progressed, but was noted by two observers. (See description of a somewhat similar phenomenon p. 152 below.)

Reno, Nev.—Observations of Ci. and Ci.-St. also were made, but these show a uniform change of azimuth from 70° at 12 m. to 95° at 4:56 p. m.

Roswell, N. Mex.—Observations of the azimuth of Ci.-St., A.-St., and Cu. were made by means of a pocket compass. The azimuth of the Ci.-St. and A.-St. changed uniformly from 170° at 11 a. m. to 120° at 6 p. m., while during the same interval that of the Cu. changed uniformly from 220° to 270°.

Kansas City, Mo.—The azimuths of clouds were obtained by means of a nephoscope constructed by the observers, Messrs. Connor and Anderson. A circular scale ruled to degrees was fitted to a mirror 9 centimeters in diameter.

CLOUDS IN EAST TEXAS, JUNE 8, 1918.

(Explanatory description of non-instrumental observations made at College Station.)

By CHARLES F. BROOKS.

[Dated: College Station, Tex., Oct. 19, 1918.]

June 8 dawned with all factors favoring the occurrence of local showers. The wind was light, and some of the time from the east. High, cirrus clouds from the west-northwest, and cirro-cumulus clouds from the west-southwest, covered almost half the sky; and here and there were some rafts of alto-cumulus and strato-cumulus together, moving from the south-southwest.[1] These clouds at three levels were apparently the remnants of cumulo-nimbus clouds which had formed the day before (see figure). All seemed to have evaporated by 9 or 10 a. m. (90th meridian time).

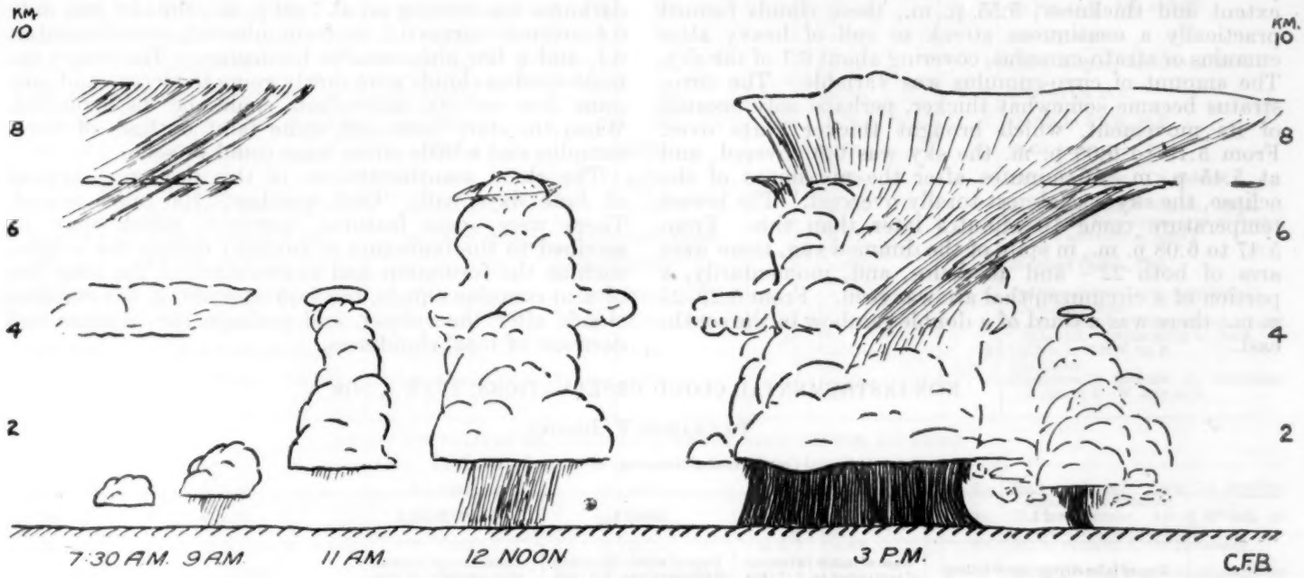

Fig. 1.—Composites from cloud sketches, June 8, 1918, at College Station, Tex.

Two hours of only partially interrupted sunshine started the usual convectional currents. On account of the dampness of the air, the dew-point in the rising columns was soon reached. So cumuli began to form at 7:25 a. m. (see figure) and grew with extraordinary rapidity, covering almost two-thirds of the sky by 8 a. m. While the cloud bases were still low some of the clouds grew so thick that shortly after 9 a. m. light showers of rain occurred (see figure). The heavy clouds automatically put a damper on the rapid heating of the ground, so that convection was no longer strong enough to keep up the initial intensity. As the lower air became warmer the height at which condensation began in the ascending currents became so great that even had light rain continued to fall from the clouds the drops would probably have evaporated before reaching the ground.

By 11 a. m. most of the cumulus domes were beginning to reach the alto-cumulus level, which was still moist after the evaporation of the clouds there only a few hours before. As the convectional columns began to disturb this moist layer the sky became dotted with lenticular clouds, most of which were soon entered and swallowed up by the cumuli (see figure). Many of the cumuli now had grown into cumulo-nimbi, and were spreading their flat tops above the other clouds. Soon some of the heads reached higher and produced caps in the next moist layer above—that is, in the cirro-cumulus level (see figure).

With the formation of cumulo-nimbus clouds the convectional currents had become established on such a scale that most of the small cumuli disappeared. Thus there were large clear patches; and, likewise there were showers of considerable area. This was to be expected, for the larger clouds not only called for larger areas of descending air, but also with their large shadows they cut off the warming of the ground. The spreading tops of the clouds in both the cirrus and cirro-cumulus levels, and also some disturbances at these levels, began to cover the sky with various forms of cirrus; while local spreadings of the large convectional clouds at a lower level, where there seemed to be a temperature inversion, added some sheets of alto-stratus and alto-cumulus. The cloudiness increased as these various sheet clouds spread out. An arc of a solar halo became visible. Streaks of falling rain were to be seen in several directions, five showers being distinguishable for an hour early in the afternoon (see figure). These would form, travel slowly northward, spread out, become thinner and evaporate—cloud first. One such brought a shower at College Station from 3:02–15 p. m.

After 3 p. m. disintegration was the rule. At about 3:30 a relatively cool breeze came from the northeast, apparently from under an evaporated shower. This seems to have caused some of the cumuli to evaporate, by interfering with the rising currents which sustained them. The bases of the cumuli for the time being moved from the east while their tops came from the south. The cirrus and cirro-stratus now covered half of the sky, and the cumulus clouds a third more. A thickening cumulo-nimbus top drove slowly overhead from the west-northwest; and as its shadow deepened, the cumuli disappeared until they were to be seen only around the edges where there were clear spaces. In the southeast, a line of cumuli marked the open sky beyond the cirro-stratus sheet over us.

[1] Details of the 49 cloud observations are given in the table at the end of this article The development of the clouds is shown schematically in the figure.

When the solar eclipse began at about 4:35 p. m. the cirrus and cirro-stratus clouds covered 0.4 of the sky and 0.2 more were covered by cumulus and cumulo-nimbus clouds. A large cumulo-nimbus in the north to north-northwest kept growing backward as fast as its top was blown eastward, and time and again its rising domes would be shrouded for a few minutes in delicate scarf clouds. Local movement in and under the cirro-stratus clouds resulted in occasional appearances of cirro-cumulus waves or patches. By 5 p. m. the amount of cirro-cumulus was about 0.1, if all the scattered patches could be added together. In the northwest to east, under the shadow of the top of the cumulo-nimbus centering in the north, a row of alto-cumulus began to form at 5 p. m. First these were smooth, isolated caps or patches, but when more rapid formation began at 5:20 p. m. they spread, and at the time of their maximum extent and thickness, 5:55 p. m., these clouds formed practically a continuous streak or roll of heavy alto-cumulus or strato-cumulus, covering about 0.1 of the sky. The amount of cirro-cumulus was variable. The cirro-stratus became somewhat thicker, perhaps only because of its movement, which brought thicker parts over. From 5:15 to 6:05 p. m. the sky was 0.9 covered, and at 5:45 p. m., 10 minutes after the maximum of the eclipse, the sky was almost totally overcast. The lowest temperature came 10 minutes later than this. From 5.47 to 6:08 p. m., in spite of the dimmed sun, there were arcs of both 22°- and 46°-halos, and, momentarily, a portion of a circumzenithal arc was seen. From 5:22–25 p. m., there was a third of a double rainbow in the southeast.

As the sun slowly emerged from behind the moon, the cloudiness gradually decreased, the cirro-stratus became thinner, the alto-cumulus gradually disappeared, and the cumulus clouds were rejuvenated. At the end of of the eclipse, about 6:38 p. m., the cirro-stratus and cirro-cumulus clouds occupied a little over half of the sky, and two-tenths more were covered with cumulus and cumulo-nimbus.

As the sun got low, the shadows in the northeast became heavy; and the alto-cumulus streak began to reappear at 7 p. m. A few minutes later the sun set behind the top of a cumulo-nimbus cloud. The cloudiness became 0.6 at 7:15 p. m. At that time, cumulo-nimbus or "false" cirrus clouds extended around the northern horizon from the west-southwest to east-northeast. In the west, some heavy masses of falling rain were silhouetted against the low light. When darkness was coming on at 7:30 p. m., the sky was only 0.4 covered—cirrus 0.1, cirro-cumulus 0.2, cumulo-nimbus 0.1, and a few alto-cumulus lenticulars. The heavy cumulo-nimbus clouds were slowly going to pieces; and now some five or six individuals could be distinguished. When the stars came out, some faint outlines of cirro-cumulus and a little cirrus haze could be seen.

The cloud transformations of this day were typical of June days, with "Gulf weather" 100 miles inland. There were some features, however, which may be ascribed to the reduction in sunlight during the eclipse: such as the formation and evaporation of the long line of alto-cumulus clouds, the rejuvenation of the cumulus clouds after the eclipse, and perhaps the increase and decrease of total cloudiness.

NON-INSTRUMENTAL CLOUD OBSERVATIONS, JUNE 8, 1918.

By CHARLES F. BROOKS.

[Signal Corps School of Meterology at College Station, Tex.]

Ninetieth meridian time.	Level 1. Top of false cirrus; snow falling through Level 2. Movement from WNW.		Level 2. Base of minor inversion of temperature, 2 (?) km. below Level 1. Movement from WSW.		Level 3. Base of minor inversion of temperature, 4 (?) km. below Level 2. Movement from SSW.		Levels 4 and 5. Considerable stratum with uniform (?) temperature gradient. L. 4 from SSW. L. 5 from S. to E.		Total cover, tenths.	Remarks.
	Tenths of sky covered.	Kinds.	Tenths of sky covered.	Kinds.	Tenths of sky covered.	Kinds.	Tenths of sky covered.	Kinds.		
A. M.										
6	3+1	Ci.	oo	Ci.Cu.	1	A.Cu. & St.Cu.	0	None.	4	Overflow remnants.
7	2+1	Ci.		? (obscured ?).	4	St.Cu. & A.Cu.	0	None.	6	Do.
8	1+1	Ci.	oo	Ci.Cu.	0 (?)	None (?).	6	Cu.	7	1st Cu. at 7:25.
9	0 (?)	None (?).	0 (?)	None (?).	0 (?)	None (?).	7	Cu.Nb., Cu.	7	Light rain just after 9.
10	0	None.	0	None.	0	None.	5	Cu.	5	
11	0	None.	0	None.	oo	A.Cu.	?	Cu.	?	A.Cu. lenticulars.
11:30	0	None.	0	None.	oo+1	A.Cu.	6	Cu.	6	A.Cu. lenticulars and scarfs.
12	0	None.	0	None.	oo+1	A.Cu.	7	Cu.Nb., Cu.	7	Do.
P. M.										
12:33–12:38	oo	Ci.	oo	Ci.Cu.	1+1	A.Cu.	oo	Cu.Nb.	4	Light rain 12:15. Ci.Cu. and A.Cu. lenticulars and scarfs.
							3	Cu.		
1:00– 1:05	oo+1	Ci.	2+1	Ci.Cu.	1	A.Cu. & St.Cu.	oo	Cu.Nb.	6	St.Cu. overflow from Cu.Nb.
							3	Cu.		
1:30– 1:40	1+1	Ci. & Ci.St.	oo	Ci.Cu.	1	A.Cu. & St.Cu.	3	Cu.Nb.	7	Ci.Cu. scarfs. Halo 1:25–40, 45–50.
							2	Cu.		
2:08– 2:10	1+1	Ci. & Ci.St.	0	None.	2	A.Cu.	1	Cu.Nb.	7	St.Cu.: evaporating Cu.Nb.
					1	St.Cu.	2	Cu.		5 showers in sight.
2:31– 2:35	oo+2	Ci. & Ci.St.	oo	Ci.Cu.	2	A.Cu. & St.Cu.	2	Cu.Nb.	8	Some lenticular A.Cu.
							4	Cu.		4 showers in sight.
3:02– 3:13	oo+2	Ci.	0 (?)	None in sight.	3	St.Cu. & A.St.	3 (?)	Cu.Nb.	9	Light rain, 3:02–3:15.
							3 (?)	Cu.		
3:35– 3:40	5	Ci. & Ci.St.	0	None.	1	St.Cu.	?	Cu.Nb.	8	3 showers in sight.
								Cu. (base from east).		Cu. leaning E. or SE., slow anticyclonic cloud whirl.

NON-INSTRUMENTAL CLOUD OBSERVATIONS, JUNE 8, 1918—Continued.

Ninetieth meridian time.	Level 1. Top of false cirrus; snow falling through Level 2. Movement from WNW.		Level 2. Base of minor inversion of temperature, 2 (?) km. below Level 1. Movement from WSW.		Level 3. Base of minor inversion of temperature, 4 (?) km. below Level 2. Movement from SSW.		Levels 4 and 5. Considerable stratum with uniform (?) temperature gradient. L. 4 from SSW. L. 5 from S. to E.		Total cover, tenths.	Remarks.
P. M.	Tenths of sky covered.	Kinds.	Tenths of sky covered.	Kinds.	Tenths of sky covered.	Kinds.	Tenths of sky covered.	Kinds.		
					ECLIPSE BEGAN ABOUT 4:35.					
4:35- 4:40	4	Ci. & Ci.St.	0	None.	?	None noticed.	1 1	Cu.Nb. Cu.	6	Cu. where sun shines. Halo.
4:41- 4:44	5	Ci. & Ci.St. & A.St.	oo	Ci.Cu.	?	Do.	1 1	Cu.Nb. Cu.	7	Cu.Nb., in N.-NE. and SE.
4:45- 4:49	?	Ci. & Ci.St.	?	Ci.Cu.	?	Do.	1 oo	Cu.Nb. Cu.	7	Scarfs in north.
4:50- 4:52	7	Ci. & Ci.St.	?	Ci.Cu.	?	Do.	1 oo	Cu.Nb. Cu.	8	Ci.Cu. forming, waved from NNW.
4:53- 4:56	6 (?)	Ci. & Ci.St. & A.St.	1 (?)	Ci.Cu.	?	Do.	1 oo	Cu.Nb. Cu.	8	Scarf on Cu. in S.
4:57- 4:59	6	Ci. (2) & Ci.St. (3) & A.St. (1).	oo	Ci.Cu.	?	Do.	oo 1	Cu.Nb. Cu.	7	Cu.Nb. in NNW. to E.
5:00- 5:03	4	Ci. & Ci.St.	1	Ci.Cu.	1	A.Cu.	1 oo	Cu.Nb. Cu.	7	Ci.Cu. increasing. Halo.
5:04- 5:07	?	Ci.St.	1	Ci.Cu.	?	A.Cu.	? ?	Cu.Nb. Cu.	7	4 showers visible. Cu. thicker.
5:08- 5:11	6	Ci. (2) & Ci.St. & A.St.	oo	Ci.Cu.	?	A.Cu.	? oo	Cu.Nb. Cu.	8	5 showers visible. Cu.Nb. cloud in SE. with false cirrus tops at levels 1 and 2 and shelf at level 3.
5:12- 5:16	5	Ci.St. (4) & A.St. (1).	oo	Ci.Cu. (evap.).	1 (?)	A.Cu. (caps).	? ?	Cu.Nb. Cu.	8	
5:17- 5:21	8	Ci.St. (7) & A.St. (1).	oo	Ci.Cu.	?	A.Cu.	? ?	Cu.Nb. Cu.	9	Rainbow in SE., 1 leg.
5:22- 5:25	7	Ci.St. (6) & A.St. (1).	0	None.	oo	A.Cu.	1 1	Cu.Nb. Cu.	9	Double rainbow in SE. (southern ½). A.Cu. lenticular.
5:26- 5:29	8	Ci. & Ci.St. & A.St. (1).	0	None.	oo	A.Cu.	1 oo	Cu.Nb. Cu.	9	A.Cu. lenticular, some waved. Faint halo still. Swifts going to roost.
5:30- 5:34	8	Ci. & Ci.St. & A.St. (1).	oo	Ci.Cu.	?	A.Cu.	? ?	Cu.Nb. Cu.	9	Cu.Nb. in NNW. to E. Cu. flatter.
5:35- 5:39	8	Ci. & Ci.St. & A.St. (1).	0	None.	oo	A.Cu.	? ?	Cu.Nb. Cu.	9	Considerable increase in lenticular. A.Cu. in E.-W. line in N.
					ABOUT 5:37; ECLIPSE MAXIMUM—SUN ABOUT NINE-TENTHS COVERED.					
5:40- 5:44	8	Ci. & Ci.St.	0	None.	oo	A.Cu.	oo oo	Cu.Nb. Cu.	9—	Halo continued. Large Cu. growing; small Cu. decreasing.
5:45- 5:49	8	Ci. & Ci.St.	oo	Ci.Cu.	oo	A.Cu.	oo + 1 oo	Cu.Nb. Cu.	9+	Ci.Cu. lenticular. Arc of 46°-halo appeared above sun at 5:47.
5:50- 5:53	7	Ci. (1) & Ci.St. (6) & A.St.	0	None.	1 1	A.Cu. St.Cu.	oo + 1 oo	Cu.Nb. Cu.	9—	St.Cu. in south A. Cu. increasing.
5:54- 5:58	7	Ci. (1) & Ci.St. (6).	0	None.	1	A.Cu. & St.Cu.	oo + 1 oo	Cu.Nb. Cu.	9—	A.Cu. & St.Cu. almost continuous from WNW. to E. 3 showers E.-S., one NNW.-E.
5:59- 6:05	7	Ci. (1) & Ci.St. (6).	oo	Ci.Cu.	1	A.Cu.	oo + 1 oo	Cu.Nb. Cu. & St.Cu.	9	Shiny Ci.Cu. lenticulars in N.-NW. Some A.Cu. lentic. 3 Cu.Nb. clouds.
6:06- 6:08	9	Ci. (2) & Ci.St. (7).	oo	Ci.Cu.	oo	A.Cu.	oo oo	Cu.Nb. Cu. & St.Cu.	9	Brilliant lenticular Ci.Cu. under sun. Caps and scarfs in N. & E. Cu.Nb. in SSW., and NW.-ENE. 46° halo just gone, parhelia (22°) still present.
6:09- 6:14	8	Ci. (1) & Ci.St. (7).	oo	Ci.Cu.	oo	A.Cu.	oo oo	Cu.Nb. Cu. & St.Cu.	8	
6:15- 6:17	7	Ci. (1) & Ci.St. (6). (Ci.St. 8 at 6:18).	oo	Ci.Cu.	oo	A.Cu.	oo 1	Cu.Nb. Cu. & St.Cu.	8—	
6:21- 6:24	8	Ci. & Ci.St.	oo	Ci.Cu.	oo	A.Cu.	oo oo	Cu.Nb. Cu. & St.Cu.	8+	Ci.Cu. lenticulars disappearing.
6:25- 6:29	6	Ci.St.	oo	Ci.Cu.	oo	A.Cu.	oo oo	Cu.Nb. Cu. & St. Cu. (thickening)	7	A.Cu. line disappearing. CiCu. lenticulars mostly gone, new rafts formed NE. and W.
6:30- 6:33	?	Ci.St.	oo	Ci.Cu.	oo	A.Cu.	oo 1	Cu.Nb. Cu. & St.Cu.	7	Thick Ci.St. decidedly thinner. Some Ci.Cu. forming within Ci.St..
6:34- 6:37	5	Ci.St.	1	Ci.Cu.	oo	A Cu.	oo oo	Cu.Nb. Cu.	7—	Parhelion. A.Cu. streak practically gone.
					END OF ECLIPSE ABOUT 6:38.					
6:38- 6:42	4	Ci.St.	2	Ci.Cu.	oo	A.Cu.	1 oo	Cu.Nb. Cu.	7	Ci.St. thinner. Some Ci.Cu. above Ci.St.; some new Ci.Cu. below, from WSW.
6:43- 6:49	4	Ci.St. (3) & Ci. (1).	1	Ci.Cu.	oo	A.Cu.	1 oo	Cu.Nb. Cu.	7	Lower Ci.Cu. thickening. Cu. in S.-W. and N.
6:50- 6:53	4	Ci.	2	Ci.Cu.	0	None.	1 oo	Cu.Nb. Cu.	7	Ci.Cu. with delicate lavender and green sheen. Large Ci.Cu. cloud. Cloud points cast shadows on remainder of the cloud.
6:58- 7:03	3	Ci.	2	Ci.Cu.	oo	A.Cu.	2	Cu.Nb.	7	Ci.Cu. still iridescent. Cu.Nb. in NW.-ENE. and W.
7:08- 7:11	2+1	Ci.	2	Ci.Cu.	oo	A.Cu.	2	Cu.Nb.	6	Some new, balled Ci.Cu., with waves from NW.
7:18- 7:22	1+1	Ci.	2	Ci.Cu.	oo	A.Cu.	2	Cu.Nb.	5	Snow falling through A.Cu. layer in SSW.
7:27- 7:30	oo+1	Ci.	2	Ci.Cu.	oo	A.Cu.	(1½) 2	Cu.Nb.	4	Some waves in false Ci.A.Cu. mostly lenticular. 5 or 6 showers visible WSW., NW.xW., NW., N.xW., N.xE., NE.xE.(?)

Weather Bureau abbreviations for cloud forms are used.

In the table above, two numbers such as "1+2," indicate that one-tenth of the sky was covered by the form indicated, and that there is every reason to believe that there were two-tenths more of the same cloud form behind a lower sheet, which at the time of the observation actually covers those two-tenths of the sky.

"oo" indicates that the covering is less than about 7 per cent.

It will be noted in certain instances that the total sky cover exceeds the sum of the individual cloud covers indicated. In these cases, there may be two or three forms covering only 5 per cent or less of the sky each, which altogether would make a tenth. It would be inaccurate to designate any one of these forms as covering a tenth of the sky, in order to make the total conformto the total cover.

THE REFLECTING POWER OF CLOUDS.

By L. B. ALDRICH.

(Smithsonian Misc. Col., vol. 69, No. 10, Washington, 1919.)

Measurements of sky brightness were made by the author in cooperation with officers and men of the balloon school of the Army at Arcadia, Cal., on September 17, 1918. They may be considered a continuation with improved facilities of the measurements already discussed in the Annals of the Astrophysical Observatory, Volume II. The author's summary follows:

SUMMARY.

A pyranometer suspended below the basket of an Army observation balloon was used to measure the reflecting power of a level cloud surface practically filling a hemisphere of solid angle. Over 100 determinations were made. The solar air masses ranged from 2.8 to 1.2, and the sky above was cloudless and very clear. A mean value of 78 per cent is obtained. No change of total reflection depending on solar zenith distance is apparent within a range of zenith distance from 33° to 69°. A value of 43 per cent for the albedo of the earth is obtained by revision of the earlier value of Abbot and Fowle (Annals, Vol. II, p. 162) which depended on a lower value of cloud reflection based on observations over but a small part of a hemisphere.—H. H. K.

AN I MPROVEMENT IN THE POLE STAR RECORDER.

By B. C. KADEL.

[Dated: Weather Bureau, Washington, Apr. 3, 1919.]

An instrument known as the pole star recorder has been recently completed in the Instrument Division of the Weather Bureau for use at the Weather Bureau observatory at the University of Chicago (see fig. 1). The pole star is not at the true north pole of the celestial sphere, but is about 1¼ degrees from it, and therefore appears to move each day about the true pole in a circular path whose diameter is about 2½ degrees. If a camera is pointed toward Polaris, and the shutter is opened after dark and closed before daylight next morning, we shall find on the sensitized plate or film a curved line made by the light from the pole star, provided the sky about the star was clear. When clouds are present all night the plate will be blank, and when the night is one of varying cloudiness, a broken curved line will result (see figs. 6, 7, and 8).

It is evident, therefore, that a camera offers a fairly reliable means of recording cloudiness at night without any complicated mechanical parts, although the portion of the sky about Polaris may not always represent the condition of the sky as a whole. Prof. E. C. Pickering, of Harvard University, is said to have been the first to employ the device, and Mr. S. P. Fergusson [1] published in 1905 a description of an improved form.

Several years ago Prof. C. F. Marvin designed a clock attachment for opening and closing the shutter of the camera at a predetermined time, and provided a circular metallic disk or dial with time graduations cut through it, so that by interposing the disk between the sensitized plate and daylight for a fraction of a second, the time scale might be printed photographically. Orientation of the graduated disk was accomplished each day by reference to the almanac, and it was found that the men assigned to the work were quite liable to error and confusion in setting the disk.

The improvement to be described is directed to rendering the orientation of the disk a simple operation, and particularly to making the observer independent of the almanac. The disk (figs. 2 and 3), with the time scale engraved upon it as intended to be reproduced upon the sensitized film, is built into a rotating circular brass frame upon whose periphery is formed a cogwheel with 365 teeth, one tooth for each day in the year. A worm wheel that meshes with the 365-toothed wheel is turned by means of a small thumb screw attached to a shaft that projects within reach of the observer (see fig. 2). The entire device is built into a frame modeled after a standard photographic plate holder.

When the disk has been once properly oriented, it is required merely to turn the thumb screw one complete revolution each day to advance the time scale 1/365th of a revolution, and thus bring it into proper relation to the star trail. The record actually made by Polaris in sidereal time may then be read off directly in mean solar time of a standard meridian.

In order that the observer may be able to make the initial setting without reference to the almanac, there has been engraved on the rotating dial opposite selected hours the date on which Polaris culminates at that particular hour (see fig. 3.) When the particular hour mark mentioned coincides with an arrow engraved on the nonrotating part of the device at the position corresponding to upper culmination, the dial is approximately correct for the date indicated, probably within the limits of accuracy of the instrument. Final adjustment to the actual date desired is accomplished by turning the thumb screw the required number of revolutions.

A removable circular section of clear glass has been set into the central portion of the space within the time dial, to provide a means of identification of the record. The glass is first smoked, after which the date is stamped on with an uninked rubber stamp, which removes the soot, so that the light may shine through.

The entire time-scale device is inserted between the sensitized film or plate and the lens of the camera in the

[1] Fergusson, S. P.: "The Automatic Polar Star Light Recorder"; Quart. Jour. Roy. Meteorological Soc., 31, 1905, p. 309-313, and Amer. Meteorological Jour., June, 1894, p. 62-64.

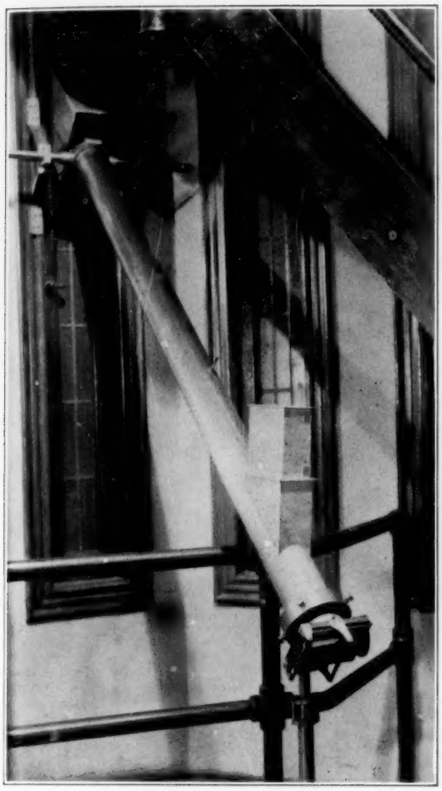

FIG. 1.—Pole Star recorder, complete, as installed at a north window.

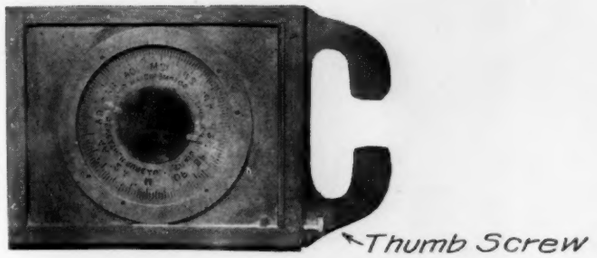

FIG. 2.—Time-scale printing device.

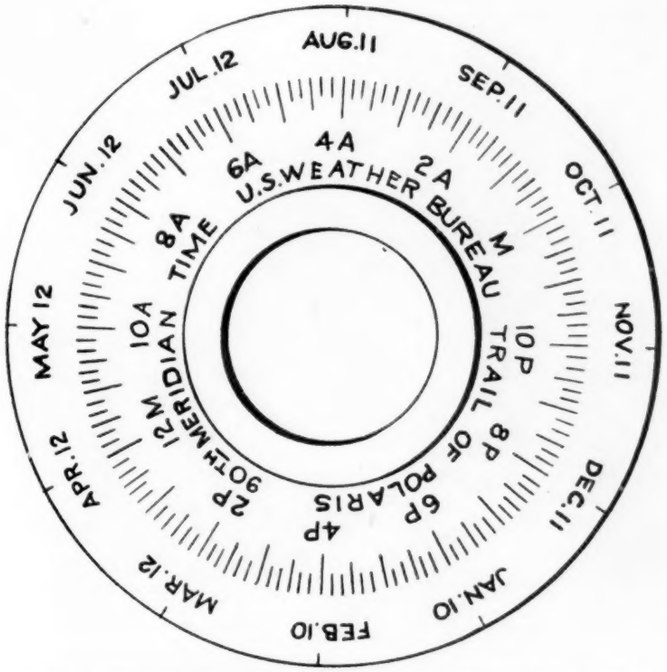

FIG. 3.—Time-scale printing device. Dates and coincidence lines at outer rim are engraved on the plate. Other data are cut through the plate.

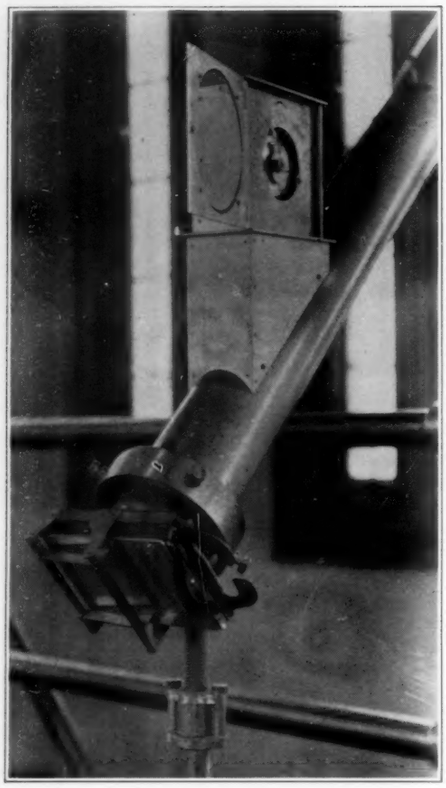

FIG. 4.—Time-scale printing device shown in position in front of plate holder.

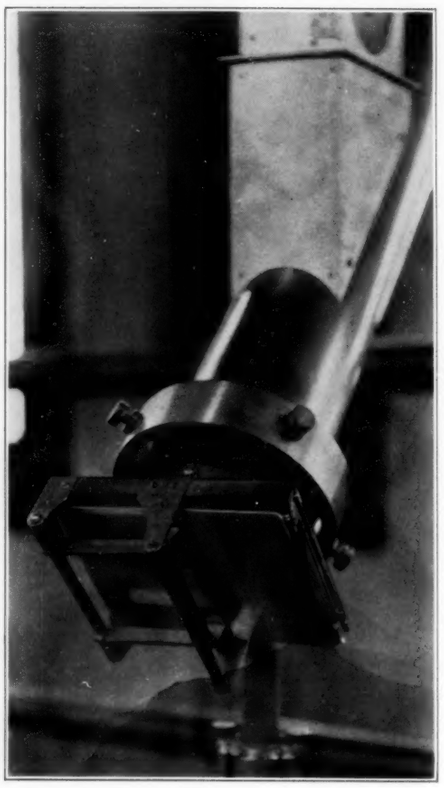

FIG. 5.—Time-scale printing device removed. Camera now ready for night's record.

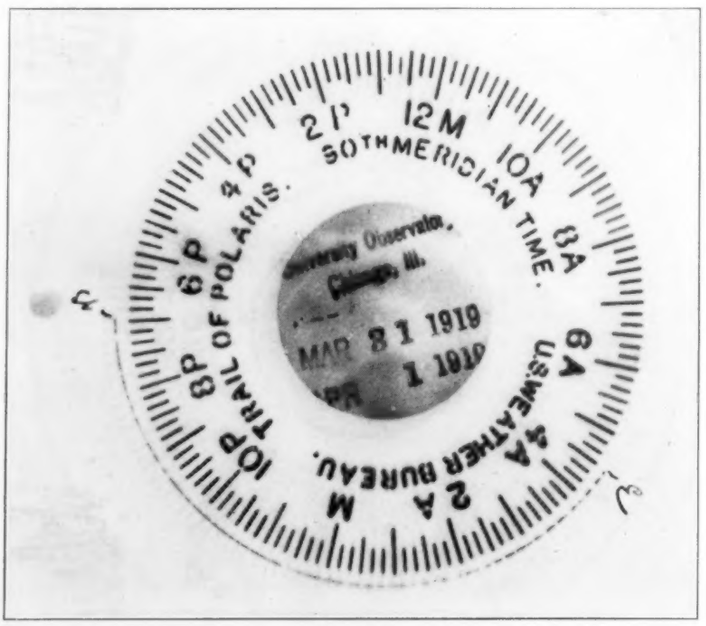

FIG. 6.—Sample record. Observer notes as follows: "Cirrus at beginning, followed by alto-cumulus, changing to alto-stratus at 2 a. m."

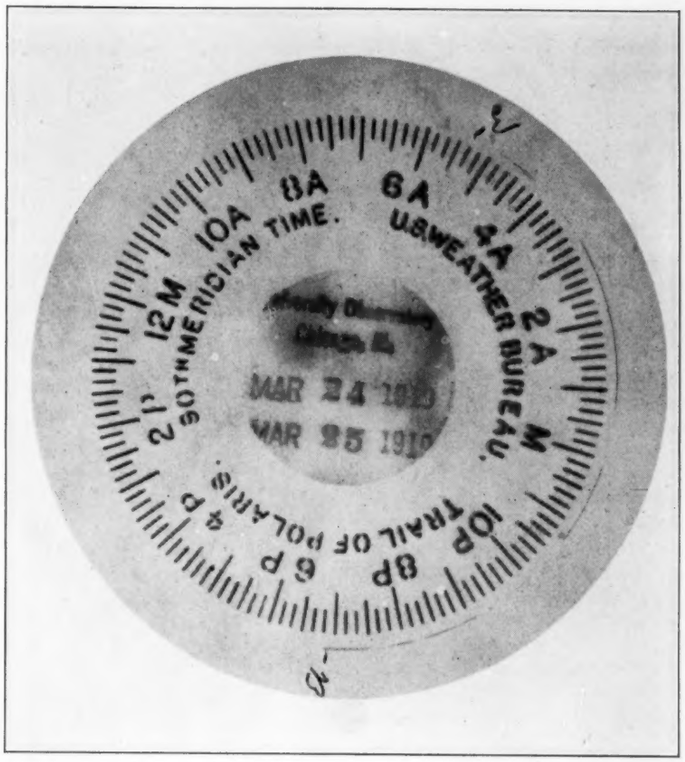

FIG. 7.—Sample record. Observer notes as follows: "Cirrus and cirro-stratus, with patches of alto-stratus."

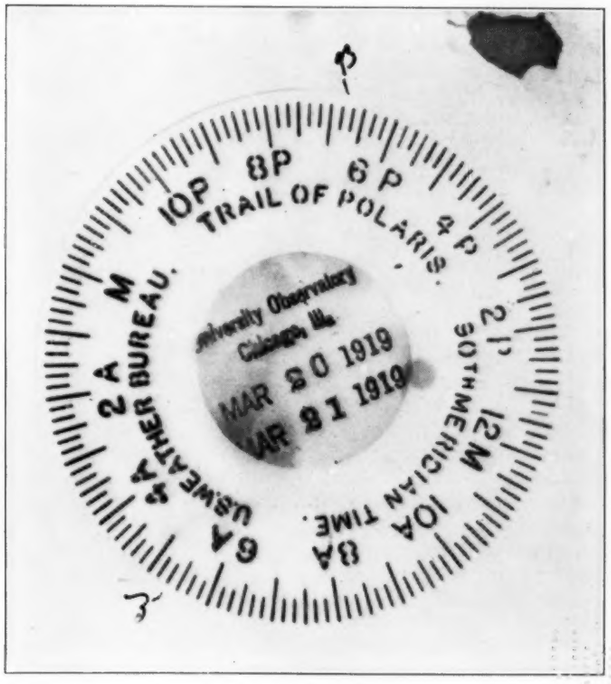

FIG. 8.—Sample record. Observer notes as follows: "Fast-moving cumulus and alto-stratus."

daytime (fig. 4), and the shutter opened for a fraction of a second, after which the time-scale device is withdrawn (fig. 5), leaving the camera clear for the night's record.

The time to open the shutter after sunset and the time to close it before sunrise in order to obtain the maximum length of record without fogging the film has been worked out as follows: An examination of exposures made by Mr. A. J. Weed during preliminary trials of the instrument discloses that the films are fogged on full moonlight nights, but not to a sufficient extent to impair the record. It may therefore be considered safe to open the shutter just at the time twilight is equal to full moonlight. Measurements made by Thiessen [1] show that this occurs when the sun is approximately 10½ degrees below the horizon. Using the formula given in the same article, the time (90th meridian time) at Chicago when twilight is equal to full moonlight has been computed as follows:

Time when the sun's altitude is −10° 30′ at Chicago.

		Apparent time.		Equation of time. (minutes.)	Including −10 minutes to reduce Chicago to 90th meridian time.	Standard time 90th meridian.	
		(p. m.).	(a. m.).			Open shutter (p. m.).	Close shutter (a. m.).
	1899.						
Jan.	1	5:34	6:26	+4	−6	5:28	6:20
	10	5:38	6:22	+8	−2	5:36	6:20
	20	5:45	6:15	+11	+1	5:46	6:16
Feb.	1	5:56	6:04	+14	+4	6:00	6:08
	10	6:07	5:53	+14	+4	6:11	5:57
	20	6:18	5:42	+14	+4	6:22	5:46
Mar.	1	6:30	5:30	+12	+2	6:32	5:32
	10	6:42	5:18	+10	0	6:42	5:18
	20	6:57	5:03	+7	−3	6:54	5:00
Apr.	1	7:14	4:46	+4	−6	7:08	4:40
	10	7:28	4:32	+1	−9	7:19	4:23
	20	7:43	4:17	−1	−11	7:32	4:06
May	1	7:58	4:02	−3	−13	7:45	3:49
	10	8:11	3:49	−4	−14	7:57	3:35
	20	8:24	3:36	−4	−14	8:10	3:22
June	1	8:35	3:25	−2	−12	8:23	3:13
	10	8:41	3:19	−1	−11	8:30	3:08
	20	8:43	3:17	+1	−9	8:34	3:08
July	1	8:41	3:19	+4	−6	8:35	3:13
	10	8:36	3:24	+5	−5	8:31	3:19
	20	8:27	3:33	+6	−4	8:23	3:29
Aug.	1	8:18	3:42	+6	−4	8:14	3:38
	10	8:00	4:00	+5	−5	7:55	3:55
	20	7:45	4:15	+3	−7	7:38	4:08
Sept.	1	7:28	4:32	0	−10	7:18	4:22
	10	7:15	4:45	−3	−13	7:02	4:32
	20	7:00	5:00	−6	−19	6:41	4:41
Oct.	1	6:45	5:15	−10	−20	6:25	4:55
	10	6:32	5:28	−13	−23	6:09	5:05
	20	6:19	5:41	−15	−25	5:54	5:16
Nov.	1	6:05	5:55	−16	−26	5:39	5:29
	10	5:55	6:05	−16	−26	5:29	5:39
	20	5:46	6:14	−14	−24	5:22	5:50
Dec.	1	5:38	6:22	−11	−21	5:17	6:01
	10	5:34	6:26	−7	−17	5:17	6:09
	20	5:32	6:28	−2	−12	5:20	6:16

Valuable suggestions and assistance in designing and constructing the device have been given by Messrs. S. P. Fergusson, R. N. Covert, A. J. Weed, Julius J. Martin, and others of the Instrument Division force.

Working drawings may be obtained at actual cost of blue prints by application addressed to Chief of the Weather Bureau.

[1] Kimball, Herbert H., The Duration and Intensity of Twilight. MONTHLY WEATHER REVIEW, vol. 44, November, 1916, p. 614-620.

THE DURATION OF MOONLIGHT.

[Reprinted from Meteorological Office Circular No 18., Nov. 26, 1917, pp. 3-4.]

Prof. Alexander McAdie, director of the Blue Hill Observatory, has forwarded a specimen of a moonlight record obtained at the observatory by means of a Campbell-Stokes sunshine-recorder and a strip of photographic gaslight developing paper cut to fit the groove of the recorder suitable for the occasion. The whole of the record is colored uniformly gray by direct moonlight but along the center runs a black line, about 1 millimeter wide, which represents the effect of the moonlight which is focussed by the ball of the recorder upon the paper. This line is analogous to the burnt records caused by the sun, with the difference that the moonlight record is produced by the short actinic light rays from the moon, while the sun record is due to the long heat rays from the sun. This moonlight recorder thus finds its exact counterpart in the Jordan sunshine recorder.

Certain precautions will be necessary for the successful use of the Campbell-Stokes instrument as a moonlight recorder.

(1) The appropriate groove must be found for the day in question from the table of moon's declination in the Nautical Almanac or in Whitaker's Almanac. The summer groove is to be used when the moon's declination is greater than 9°N., the winter groove when it is greater than 9°S., and the equinoctial groove for intermediate declinations. As the moon passes through a complete cycle in declination once in a lunar month, whereas the sun passes through its cycle once a year, changes of the moon's declination are very rapid, and care will be required to change the groove when necessary. The range of the moon's declination is somewhat greater than that of the sun, but the ordinary sunshine recorder would probably just serve to obtain a complete set of moonlight records.

(2) The sensitive paper must be inserted not earlier than an hour after sunset and removed not later than an hour before sunrise; otherwise it will be completely fogged by daylight.

(3) The meridian position of the record may be indicated on the paper before it is removed from the groove by making a prick opposite the "noon" mark of the recorder. The time corresponding with this mark is the "Hour of moon's southing," and is given in the M. O. Calendar.

(4) The time scale of the moonlight recorder is a shade less open than that of the sun recorder, owing to the moon's motion in right ascension. If the length of the trace is measured on the scale provided for sunshine, the duration of moonlight may be found by adding 3 per cent to the measurement.

The observer who is interested in astronomy and the theory of the sunshine recorder will find in the use of his instrument as a moonlight recorder a very interesting and instructive exercise. If the recorder were used exclusively for moonlight recording the early rising entailed in summer by the necessity of removing the moonlight record before daybreak could be avoided by arranging for a suitable light-tight drop cover to be released at a pre-determined hour through the agency of an alarm clock.

ON THE RELATIONS OF ATMOSPHERIC PRESSURE, TEMPERATURE, AND DENSITY TO ALTITUDE.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Apr. 22, 1919.]

The relations of atmospheric pressure, temperature, and density to altitude are of importance to aviators and to aeronautical engineers, in order that laboratory tests may be correlated with performance under flight conditions. As a basis for these relations, the meteorologist has to offer the average free air atmospheric temperature, pressure, and humidity as determined by means of recording instruments carried to the desired altitudes by kites or balloons, and the hypsometric formula, which latter represents with great accuracy the variation of pressure with height when we know the temperature and humidity variations.

Unfortunately, observations show that the relations of temperature and humidity to height vary from day to day, and from hour to hour of the same day, especially below an altitude of about 3,000 meters (10,000 feet), so that the actual relations at any time rarely or never correspond to the average conditions. For this reason engineers generally prefer to employ simpler expressions for the relations of air temperature and pressure to height than are given by observations and the hypsometric formula, respectively. For the temperature-altitude relation they generally prefer a straight-line relation, as, for example, a fall of 1° F. per 300 feet increase in elevation; and in the equation expressing the pressure-altitude relation the humidity term is often omitted.

It is possible to select a straight-line temperature-altitude relation that will approximate actual relations up to

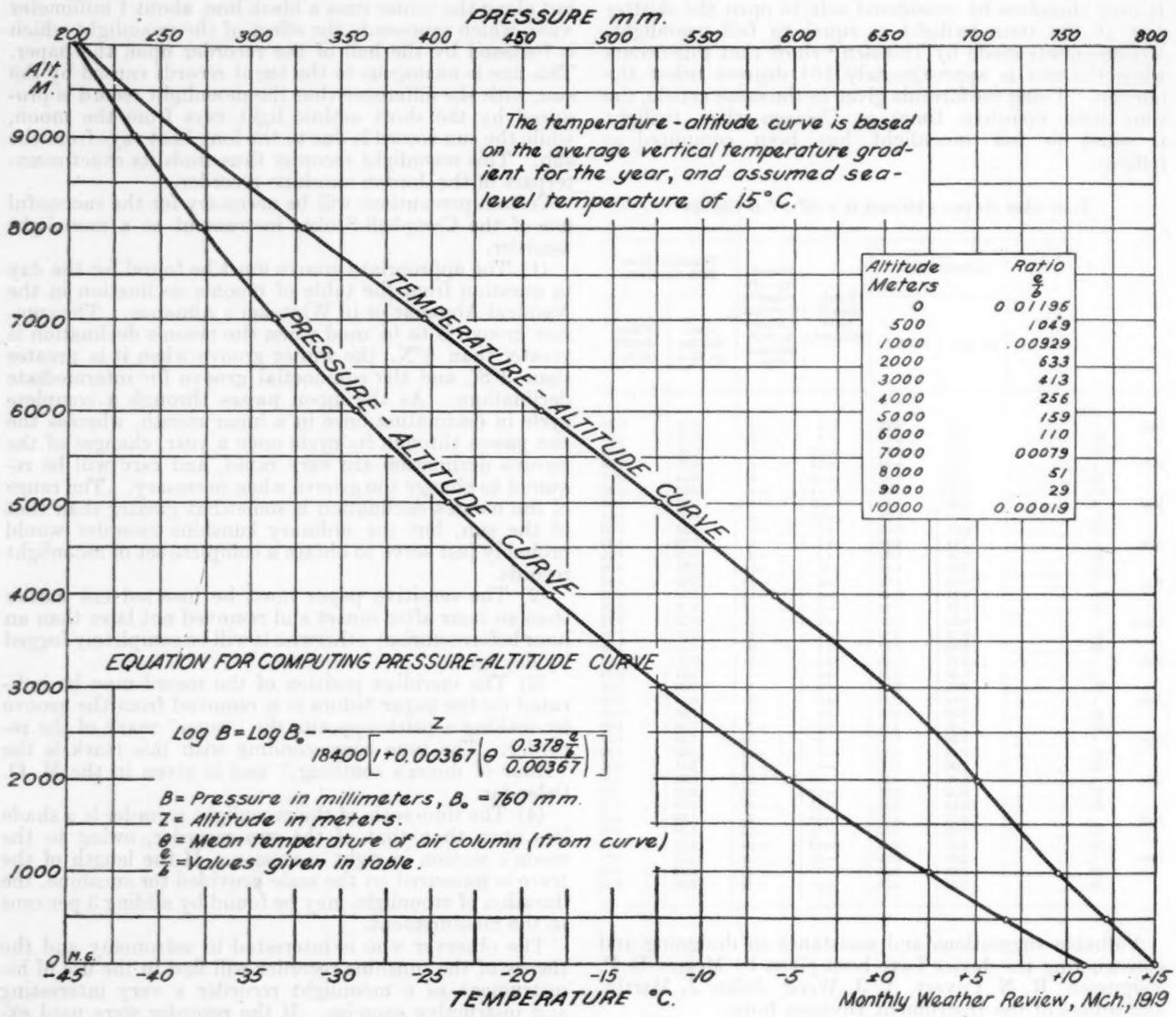

FIG. 1.—Temperature-altitude and pressure-altitude curves. (A plus sign should follow θ in the equation above.)

a height of about 10,000 meters (30,000 to 40,000 feet). Above this height, however, as the lower limit of the stratosphere is approached, the decrease in temperature with increase in altitude becomes rapidly less, so that a straight-line relation that applies in the lower layers of the troposphere will here give temperatures too low by an amount that increases rapidly with altitude. Therefore, it must be understood that these simplified equations can be employed to express atmospheric temperature, pressure, and density relations to height, only up to the altitude given above.

Table 1, in metric measures, and Table 2, in English measures, give atmospheric temperatures and densities at different heights under approximately average conditions for the east-central part of the United States. The assumed sea-level pressure, B_0, temperature, t_0, and vapor pressure e_0, are, respectively, $B_0=760$ mm. (29.92 in.), $t_0=15°$ C. (59° F.), and $e_0=9.1$ mm. (0.36 in.), and the assumed vertical distribution of temperature and water vapor corresponds to the annual means given by Gregg,[1] and reproduced in figure 1. This vertical distribution of temperature is also in close agreement with that given by Humphreys [2] for the warm part of the year. The hypsometric formula employed in computing the air pressure, B, is given in the figure, and in the heading of each table.

For θ, the mean temperature of the air column obtained by means of the equation that follows has been employed:

$$\theta=\frac{t_0+2t_1+2t_2+\ .\ .\ .\ .\ .\ +2t_{n-1}+t_n}{2n}$$

where t_0, t_1, t_2, ... t_{n-1}, t_n, represent the temperatures from the bottom to the top of the air column observed at equal intervals of height, as 500 meters or 1,000 feet. Actually, the temperature should be obtained by taking the harmonic mean of the temperature with respect to altitude, thus:

$$\frac{2n}{T}=\frac{1}{T_0}+\frac{2}{T_1}+\frac{2}{T_2}+\ .\ .\ .\ .\ .\ +\frac{2}{T_{n-1}}+\frac{1}{T_n}$$

where $T=\theta+273°$ C., or $\theta+459.4°$ F., and $T_0=t_0$, $T_1=t_1$, etc. expressed in degrees on the Absolute scale. Unless the temperatures cover a wide range, however, the increased accuracy of the result obtained from the use of the harmonic mean in place of the arithmetical mean does not compensate for the additional labor involved, and especially when we are dealing with approximate mean values only.

The equation for computing the atmospheric density, ρ, which is also given in the headings of Tables 1 and 2, gives for the average surface density 1.220 kilograms per cubic meter, as compared with 1.293 kilograms per cubic meter for dry air at tempearture 0° C. under 760 millimeters pressure, which is universally accepted as *standard* air density.

[1] Gregg, Willis R. Mean values of free-air barometric and vapor pressures, temperatures, and densities over the United States. MONTHLY WEATHER REVIEW, January, 1918, 46:11-21.

[2] Humphreys, W. J. Temperatures, pressures, and densities of the atmosphere at various levels in the region of northeastern France. This REVIEW, p. 159, fig. 1.

TABLE 1.—*Average air temperatures and densities at different altitudes.*[1] *Metric measures.*

$$\text{Log. } B=\text{Log. } B_0-\frac{Z}{18400\left[1+0.00367\left(\theta+\frac{0.378\frac{e}{b}}{0.00367}\right)\right]}$$

$\rho=\text{density}=\frac{B-0.378e}{T}\times 0.35921$; standard density = 1.293 kg./cu. m.

Altitude.	Pressure.	Temperature.	Vapor pressure.	Atmospheric density.	
				Per cent standard.	Per cent surface.
Meters.	*mm.*	*°C.*	*mm.*		
0	760.0	15.0	9.10	94.4	100.0
500	716.2	12.3	7.54	89.8	95.2
1,000	674.5	9.6	6.29	85.4	90.5
2,000	597.4	5.1	3.80	77.0	81.6
3,000	527.9	0.1	2.19	69.3	73.5
4,000	465.3	− 6.0	1.20	62.5	66.3
5,000	408.9	−12.5	0.65	56.4	59.7
6,000	358.2	−19.0	0.40	50.6	53.7
7,000	312.9	−25.4	0.25	45.4	48.1
8,000	272.3	−32.1	0.14	40.6	43.0
9,000	236.2	−38.7	0.07	36.2	38.4
10,000	204.2	−44.4	0.04	32.1	34.0

[1] Computed for sea-level pressure 760 millimeters, and sea-level temperature 15°C.

TABLE 2.—*Average air temperatures and densities at different altitudes.*[1] *English measures.*

$$\text{Log. } B=\log. B_0-\frac{Z}{60367\left[1+0.002039\left(\theta-32+\frac{0.378\frac{e}{b}}{0.002039}\right)\right]}$$

$\rho=\text{density}=\frac{B-0.378e}{T}\times 16.424$; $T=459.4+t$; standard density = 1.293 kg./cu. m.

Altitude.	Pressure.	Temperature.	Vapor pressure.	Atmospheric density.	
				Per cent standard.	Per cent surface.
Feet.	*Inches.*	*°F.*	*Inches.*		
0	29.92	59.0	0.36	94.4	100.0
1,000	28.86	56.0	.32	91.6	97.1
2,000	27.83	52.9	.28	88.9	94.2
3,000	26.83	49.8	.25	86.2	91.4
4,000	25.86	47.3	.22	83.6	88.6
5,000	24.92	44.9	.19	80.9	85.8
6,000	24.02	42.5	.16	78.4	83.1
7,000	23.12	40.0	.14	75.9	80.4
8,000	22.28	37.3	.12	73.5	77.9
9,000	21.46	34.3	.105	71.3	75.5
10,000	20.66	31.2	.086	69.1	73.2
11,000	19.88	27.9	.072	66.9	70.9
12,000	19.13	24.6	.060	64.8	68.7
13,000	18.40	21.3	.050	62.8	66.6
14,000	17.69	17.8	.045	60.8	64.5
15,000	17.00	14.2	.040	58.9	62.4
16,000	16.35	10.8	.035	57.1	60.5
17,000	15.72	7.4	.030	55.3	58.6
18,000	15.10	4.0	.025	53.5	56.7
19,000	14.50	0.4	.020	51.8	54.9
20,000	13.92	− 3.4	.017	50.1	53.1
21,000	13.36	− 7.2	.015	48.5	51.4
22,000	12.82	−11.0	.013	47.0	49.8
23,000	12.29	−14.8	.010	45.4	48.1
24,000	11.79	−18.4	.008	43.9	46.5
25,000	11.30	−22.0	.007	42.4	45.0
26,000	10.83	−25.6	.006	41.0	43.5
27,000	10.37	−29.2	.005	39.6	42.0
28,000	9.93	−32.6	.004	38.2	40.5
29,000	9.51	−36.0	.003	36.9	39.1
30,000	9.10	−39.2	.002	35.4	37.7

[1] Computed for sea-level pressure 29.92 inches, and sea-level temperature 59 °F. (15°C.).

It is of interest to compare the data of Tables 1 and 2 with those obtained by use of the simpler equations sometimes employed.

If we assume the same sea-level conditions as above, but disregard the term containing e in computing the density, we obtain $\rho = 1.226$ kg. per cubic meter, or about 0.5 per cent too high.

Again, if we assume the vertical temperature gradient to be 1° F. per 300 feet, we obtain for an altitude of 30,000 feet, $t = 59° - 100° = -41°$ F., which is only 1.8° F. lower than the value given in Table 2. At 10,000 feet, however, we obtain $t = 59° - 33.3° = 25.7°$ F., which is 5.5° F. lower than the value given in Table 2.

Johnson [3] has shown that the following assumed simple relations of air pressure, temperature, and density to height, give reasonably accurate results.

From the well-known Charles's law we have

$$P\frac{v}{t} = Pv^y = R = \text{constant};$$

$$v = \left(\frac{R}{P}\right)^{1/y};$$

$$W = 1/v = \left(\frac{P}{R}\right)^{1/y} = \text{weight per unit volume.}$$

Let $R^{-1/y} = c$.

Then $W = cP^{1/y}$ ..... (1)

from which c may be computed [4].

We may also write

$$-dP = cP^{1/y}dh$$

or

$$-P^{-1/y} = c\frac{dh}{dP}$$

Integrating, $-\frac{y}{y-1}P^{\frac{y-1}{y}} = ch + \text{constant}$,

and $P^{\frac{y-1}{y}} = \text{constant} - \frac{y-1}{y}ch$.

When $h = 0$,

$$P^{\frac{y-1}{y}} = P_0^{\frac{y-1}{y}}.$$

Therefore $P^{\frac{y-1}{y}} = P_0^{\frac{y-1}{y}} - \frac{y-1}{y}ch$ ..... (2)

Also, $RT = Pv = \frac{P^{\frac{y-1}{y}}}{c}$, and $T_0 = \frac{P_0^{\frac{y-1}{y}}}{cR}$

Combining this last equation with (2), we obtain

$$T = \frac{P_0^{\frac{y-1}{y}} - \frac{y-1}{y}ch}{cR} = T_0 - \frac{\frac{y-1}{y}h}{R} \quad \text{..... (3)}[5]$$

[3] Johnson, A. Atmospheric conditions affecting power. Aerial Age Weekly, Mar. 31, 1919, 9:166.

[4] Let $P_0 = 2116.2$ pounds per square foot, $t_0 = 59°$ F., and $y = 1.20$. Then $W_0 = 0.07651$ pounds per cubic foot, and $c = W_0 P_0^{-1/1.2} = 0.00012955$.

[5] $R = \frac{P_0}{W_0 T_0} = \frac{2116.2}{0.07651 \times 518.4} = 53.354$.

Assuming $y = 1.20$

Equation (1) becomes $W = cP^{1/1.2}$

Equation (2) becomes $P^{1/6} = P_0^{1/6} - \frac{ch}{6}$

$= P_0^{1/6} - 0.0000216h$ (P_0 in pounds per cubic foot, h in feet).

For temperatures, t, in Fahrenheit degrees, equation (3) becomes $t = t_0 - \frac{h}{6R} = t_0 - 0.003124h$ (h in feet).

TABLE 3.—*Average air temperatures and densities at different altitudes. English measures.*

$P^{1/6} = P_0^{1/6} - \frac{ch}{6}$; $\quad t = t_0 - \frac{h}{6R}$

Height.	Pressure.		Density.	Temperature.	Departure from mean observed temperature.
Feet.	*Inches of mercury.*	*Pounds per cubic foot.*	*Per cent.*	*° F.*	*° F*
0	29.92	2,116	100.0	59.0	±0.0
1,000	29.85	2,041	97.0	55.9	−0.1
2,000	27.82	1,968	94.1	52.8	−0.1
3,000	26.82	1,897	91.3	49.6	−0.2
4,000	25.85	1,828	88.5	46.5	−0.8
5,000	24.90	1,761	85.8	43.4	−1.5
6,000	23.99	1,697	83.2	40.3	−2.2
7,000	23.10	1,634	80.6	37.1	−2.9
8,000	22.24	1,573	78.1	34.0	−3.3
9,000	21.41	1,514	75.6	30.9	−3.4
10,000	20.60	1,457	73.3	27.8	−3.4
11,000	19.82	1,402	71.0	24.6	−3.3
12,000	19.07	1,349	68.7	21.5	−3.1
13,000	18.34	1,297	66.5	18.4	−2.9
14,000	17.63	1,247	64.3	15.3	−2.5
15,000	16.94	1,198	62.2	12.1	−2.1
16,000	16.28	1,151	60.2	9.0	−1.8
17,000	15.64	1,106	58.2	5.9	−1.5
18,000	15.02	1,062	56.3	+ 2.8	−1.2
19,000	14.42	1,020	54.4	− 0.4	−0.8
20,000	13.84	979	52.6	− 3.5	−0.1
21,000	13.28	939	50.8	− 6.6	+0.6
22,000	12.74	901	49.1	− 9.7	+1.3
23,000	12.22	864	47.4	−12.9	+1.9
24,000	11.72	829	45.8	−16.0	+2.4
25,000	11.23	794	44.2	−19.1	+2.9
26,000	10.76	761	42.6	−22.2	+3.4
27,000	10.31	729	41.1	−25.3	+3.9
28,000	9.87	698	39.7	−28.5	+4.1
29,000	9.45	668	38.3	−31.6	+4.4
30,000	9.04	639	36.9	−34.7	+4.5
36,960	.....	.....	.....	−56.5	+2.7
40,000	.....	.....	.....	−66.0	−6.2

Table 3 gives the pressure in inches of mercury and pounds per square foot, (the latter computed from equation (2), and then converted into inches of mercury); the temperature in degrees F, computed from equation (3); and the resulting density, in percentages of surface density.

Comparison with Table 2 shows a maximum difference in pressures of 0.6 per cent at a height of 22,000 feet, and a difference of 0.9 per cent in the densities at altitudes of 26,000 and 27,000 feet. The temperatures are too low up to 20,000 feet, with a maximum difference of 3.4° at 9,000 and 10,000 feet, and are too high between about 20,000 and 38,000 feet. Above this latter elevation equation (3) does not apply.

A slight change in y, and a resulting change in c, will adapt equations (2) and (3) to any desired vertical temperature gradient. Thus, $y = 1.19$ corresponds very closely to a gradient of 3°F. per 1,000 feet; and $y = 1.21$, very closely to a gradient of 1°F. per 300 feet.

TEMPERATURES, PRESSURES, AND DENSITIES OF THE ATMOSPHERE AT VARIOUS LEVELS IN THE REGION OF NORTHEASTERN FRANCE.

By W. J. HUMPHREYS, Professor of Meteorological Physics.

[Dated: Weather Bureau, Washington, D. C., Dec. 15, 1918.]

It is very desirable that summaries be made of, and generalizations drawn from, aerological data whenever they are sufficiently abundant, homogeneous and reliable to justify such treatment. The data used in the present study, because obtained at places of nearly the same latitude and of similar climates, meet these conditions as well as, if not better than, any other available; at least, with reference to the particular points discussed.

Table I, graphically represented by figures 1, 2, and 3, gives the seasonal (summer: June, July, August, and September; and winter: December, January, February, and March) and weather (cyclonic, anticyclonic, and neutral) vertical distribution of temperature in the atmosphere, in the region of northeastern France, from the surface up to 20 kilometers above sea level, as determined by 416 sounding balloon flights made from Trappes, Uccle, Strassburg and Munich. When two flights were made from the same place on the same day only one was used. With this exception, all flights attaining an altitude of 7 kilometers or more made at these stations from 1900 to 1912, inclusive (excepting December, 1912), and all now (1918) available, were used.

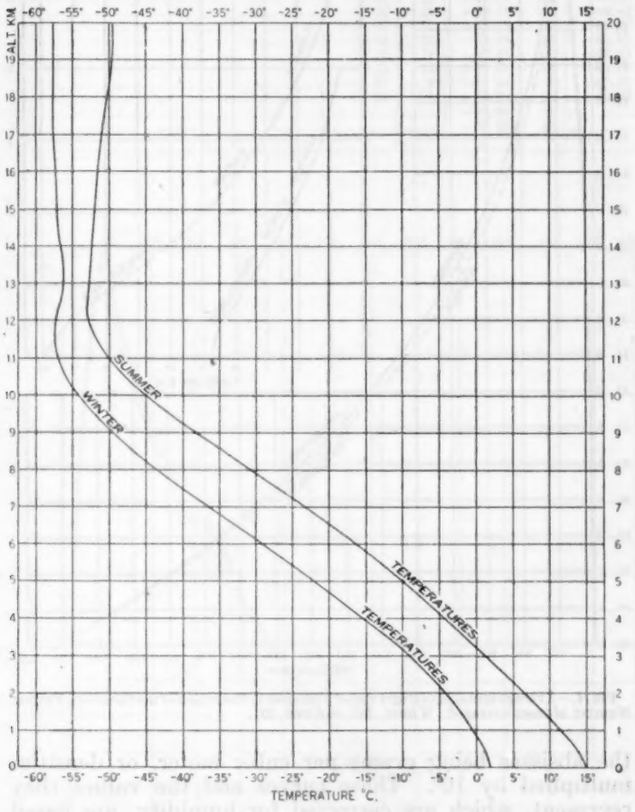

FIG. 1.—Average summer and winter temperatures in northeastern France.

Figure 1 shows the average summer and the average winter temperatures given by 231 and 185 flights, respectively. These curves beyond 8 kilometers do not give exactly, though very nearly, the averages of the observed temperatures, as they do up to that level, but show the averages of the observed temperature gradients. That is, from the level at which the number of observations began to decrease, both curves of average temperature were extended by means of their average gradients. This procedure is believed to give temperatures nearer the true average than would the averages, step by step, of the decreasing numbers of actually observed temperatures.

By averaging the data of a large number of flights, the obvious advantage is gained of correspondingly reducing the effects of accidental errors and fortuitous irregularities. At the same time, however, one serious error is introduced, namely, the gradual change of the temperature gradient between the levels of 8 or 9 and, roughly, 12 kilometers. In nearly all individual cases the change of this gradient is much more abrupt, but as it ranges over 2 or 3 kilometers and, say, 15°C. it follows that the average gives a fictitiously gradual change of the gradient.

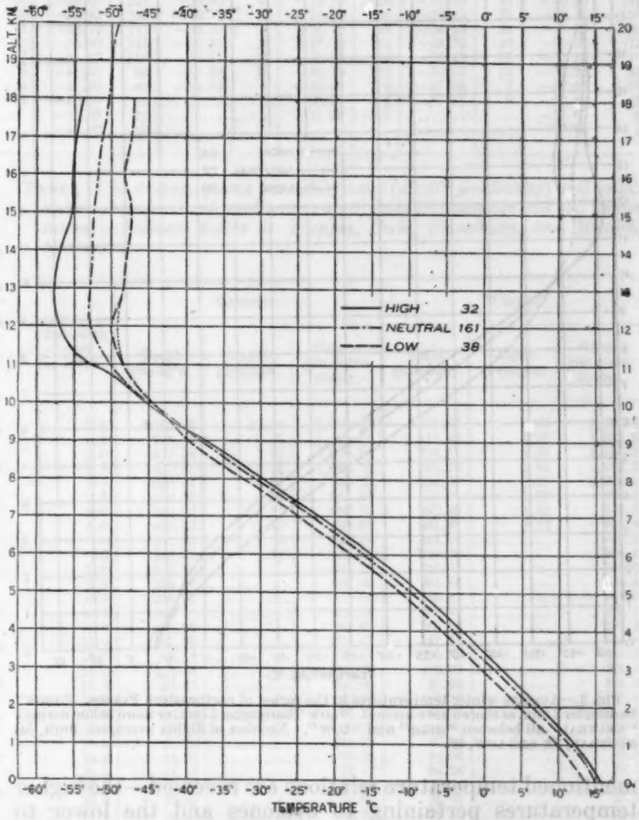

FIG. 2.—Average summer temperatures in the region of northeastern France. "HIGH" barometer 5 mm. or more above normal. "LOW" barometer 5 mm. or more below normal. "NEUTRAL" all between "HIGH" and "LOW". Number of flights averaged: HIGH, 54; NEUTRAL, 161; and LOW, 38.

Figures 2 and 3 give the results obtained on grouping the summer and winter flights, respectively, according to the surface pressure. The full line in each figure shows the average vertical temperature distribution when the barometer reads 5 millimeters or more greater than its normal value for the places and season in question.

Similarly, the broken line corresponds to pressures 5 millimeters or more below the normal, and the dot and dash line to pressures between these extremes. According to this division there were, for the summer, 32 highs, 38 lows, and 161 neutrals; and for the winter, 54 highs, 59 lows, and 72 neutrals.

It will be noticed that, on the average, the whole of the troposphere, except below about 1 kilometer—and that during winter—is warmest during the prevalence of anticyclonic conditions and coldest in cyclones. Below 1 kilometer the temperature relations are reversed during the winter, owing to the prevalence then, on clear nights, of radiational, or surface, temperature inversions. It will also be noticed that in the stratosphere the above-

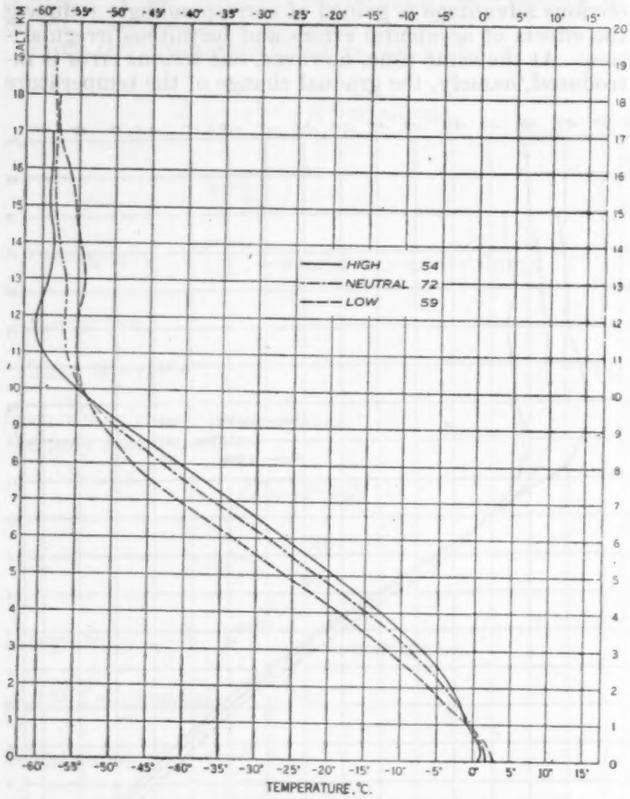

FIG. 3.—Average winter temperatures in the region of northeastern France. "HIGH" barometer 5 mm. or more above normal. "LOW" barometer 5 mm. or more below normal. "NEUTRAL" all between "HIGH" and "LOW". Number of flights averaged: HIGH, 54; NEUTRAL, 72; and LOW, 59.

mentioned temperature relations are reversed—the higher temperatures pertaining to cyclones and the lower to anticyclones.

It would be very instructive, of course, to average the temperature data according to the section of the cyclone or anticyclone in which it was obtained, but it seemed doubtful whether the flights were sufficiently numerous to justify such minute subdivision, and it, therefore, was not undertaken.

Figure 4, graphically representing the corresponding portions of Table II, gives the average summer and winter pressures, at all elevations from sea level up to 40 kilometers. These are not directly observed values, but, what comes to the same thing, values computed from the average temperatures and corrected for humidity, and the latitude and altitude effects on gravity. The temperatures used were those of Table I up to 11 and 12 kilometers for winter and summer, respectively. At and beyond 12 and 13 kilometers the winter and summer temperatures were assumed to be −57° C. and −52° C., respectively.

The summer and winter vapor pressures given in Table II and shown on the in-set to figure 4 were based, the first on the records of 193, and the second on the records of 141 individual flights.

Figure 5, representing the corresponding portions of Table II, gives the average summer and winter densities,

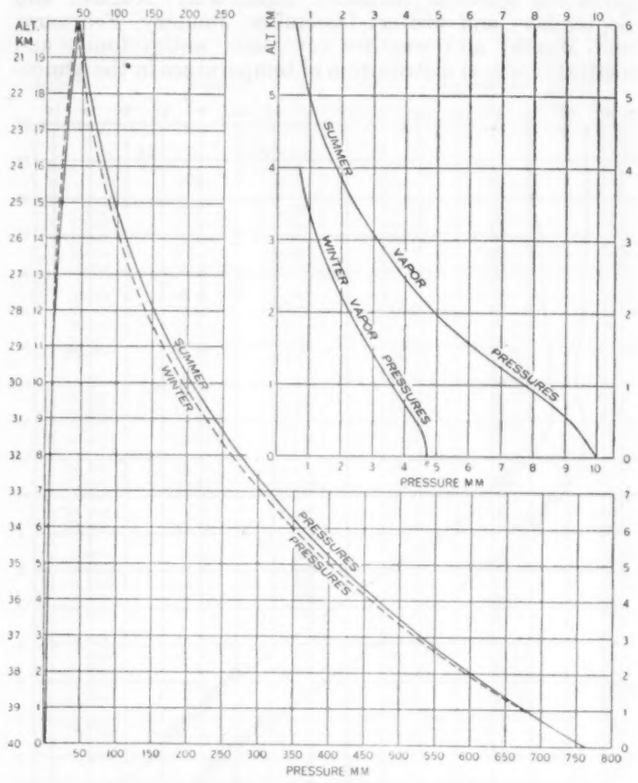

FIG. 4.—Average atmospheric and vapor pressures in the region of northeastern France. Number of cases averaged: Winter, 185; summer, 231.

the absissas being grams per cubic meter, or densities multiplied by 10^6. These curves and the values they represent, which are corrected for humidity, are based on the pressures and temperatures corresponding to figure 4.

Although in computing Table II the full hypsometric equation was used, thus correcting for humidity and the gravity effects of latitude and elevation, no account was taken of the probable differences in the percentage composition of the atmosphere at the higher levels. This was for two reasons: (*a*) because the amount of such change is uncertain, and (*b*) because, at most, it could not affect the values given, already small, by more than 1 per cent.

TABLE I.—*Average temperatures, centigrade (from average temperature gradients) from 416 sounding-balloon flights at Trappes, Uccle, Strassburg, and Munich, 1900–1912.*

[Temperature, T; number of cases, N.]

Altitude in kilometers above sea level.	Summer.								Winter.							
	High.		Neutral.		Low.		Mean.		High.		Neutral.		Low.		Mean.	
	T.	N.	T.	N.	T.	N.	T.	N.	T.	N.	T.	N.	T.	N.	T.	N.
0.0	15.54	29	14.82	121	13.58	28	14.76	178	0.67	43	1.61	55	2.85	49	1.72	147
0.5	13.98	29	13.90	121	11.93	28	13.60	178	0.87	43	1.01	55	1.77	49	1.23	147
1.0	12.39	32	12.12	161	9.98	38	11.81	231	− 0.63	54	− 0.49	72	− 0.80	59	− 0.63	185
1.5	9.57	32	9.34	161	7.23	38	9.03	231	− 1.56	54	− 1.77	72	− 3.50	59	− 2.26	185
2.0	7.09	32	6.54	161	4.55	38	6.29	231	− 2.75	54	− 3.76	72	− 5.92	59	− 4.16	185
2.5	4.37	32	3.84	161	2.12	38	3.63	231	− 4.60	54	− 6.10	72	− 8.66	59	− 6.48	185
3.0	2.00	32	1.19	161	− 0.49	38	1.02	231	− 6.92	54	− 8.65	72	−11.75	59	− 9.14	185
4.0	− 3.16	32	− 4.16	161	− 5.74	38	− 4.28	231	−12.09	54	−14.69	72	−18.44	59	−15.30	185
5.0	− 8.74	32	− 9.83	161	−11.33	38	− 9.93	231	−19.22	54	−21.49	72	−25.91	59	−22.24	185
6.0	−15.11	32	−16.15	161	−17.86	38	−16.29	231	−26.18	54	−28.40	72	−33.37	59	−29.33	185
7.0	−22.18	32	−23.12	161	−24.80	38	−23.26	231	−33.27	54	−35.80	71	−40.83	59	−36.63	184
8.0	−29.82	32	−30.59	161	−32.34	38	−30.77	231	−40.83	53	−43.10	70	−47.13	59	−43.63	182
9.0	−37.62	31	−38.08	159	−39.77	37	−38.27	227	−48.05	50	−49.70	67	−51.33	57	−49.63	174
10.0	−45.32	31	−44.88	155	−44.57	36	−44.87	222	−54.85	48	−54.30	64	−54.23	53	−54.33	165
11.0	−52.62	31	−50.08	149	−48.37	34	−50.07	214	−59.65	44	−56.50	56	−55.03	47	−56.83	147
12.0	−57.02	30	−52.68	133	−49.97	30	−52.87	193	−60.75	38	−56.80	45	−54.93	37	−57.23	120
13.0	−57.62	27	−52.78	117	−48.27	27	−52.77	171	−59.05	34	−56.70	34	−54.23	30	−56.33	98
14.0	−56.82	22	−52.48	104	−47.87	21	−52.37	147	−58.35	26	−57.70	22	−54.73	24	−56.53	72
15.0	−55.32	18	−52.38	81	−47.37	17	−51.97	116	−58.85	17	−58.20	16	−55.43	16	−57.13	49
16.0	−55.32	13	−51.68	61	−48.17	8	−51.57	82	−58.55	11	−58.30	12	−56.43	10	−57.33	33
17.0	−54.82	9	−51.18	36	−47.37	4	−51.07	49	−58.65	5	−58.00	9	−57.63	7	−57.63	21
18.0	−53.82	8	−50.38	22	−46.97	3	−50.17	33	.....	.....	−58.30	6	−57.83	5	−57.63	13
19.0	.....	.....	−49.88	17	.....	.....	−49.57	21	.....	.....	−58.20	5	.....	.....	−57.63	8
20.0	.....	.....	−48.98	15	.....	.....	−48.97	18	.....	.....	.....	.....	.....	.....	−57.63	5

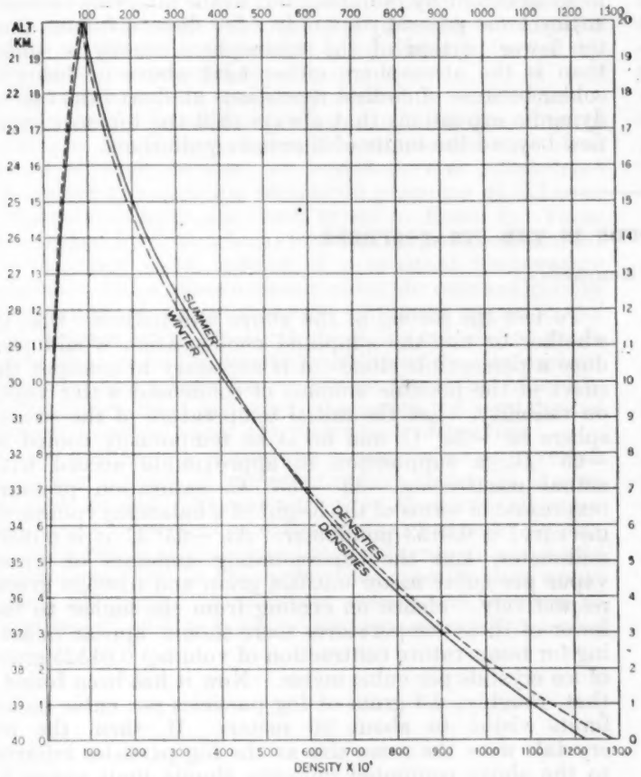

FIG. 5.—Average atmospheric densities in the region of northeastern France. Number of cases averaged: Winter, 185; summer, 231.

TABLE II.—*Average grams per cubic meter ($\rho \times 10^9$, ρ=density) and millimeters pressure (total, and water vapor) from 231 summer and 185 winter sounding-balloon flights at Trappes, Uccle, Strassburg, and Munich, 1900–1912.*

Altitude in kilometers above sea level.	Summer.			Winter.		
	Total pressure.	Vapor pressure.	Grams per cubic meter.	Total pressure.	Vapor pressure.	Grams per cubic meter.
0.0	[1] 762.55	10.46	1,224.42	[1] 763.35	4.69	1,287.58
0.5	718.75	9.17	1,159.17	717.42	4.35	1,212.31
1.0	677.24	7.81	1,099.61	674.11	3.56	1,147.23
1.5	637.81	6.21	1,046.50	633.12	2.93	1,084.23
2.0	600.31	4.97	995.19	594.37	2.27	1,025.03
2.5	564.67	3.97	945.56	557.71	1.71	970.08
3.0	530.82	3.12	897.73	522.99	1.30	919.87
4.0	468.23	1.87	808.07	458.91	0.72	826.62
5.0	411.93	1.06	726.57	401.32	.....	743.33
6.0	361.32	0.57	653.35	349.62	.....	666.41
7.0	315.84	.....	587.39	303.34	.....	596.05
8.0	274.98	.....	527.26	261.94	.....	530.41
9.0	238.39	.....	471.70	225.37	.....	468.61
10.0	205.77	.....	418.94	193.19	.....	410.34
11.0	176.95	.....	368.66	165.19	.....	355.20
12.0	151.80	.....	319.03	141.11	.....	303.43
13.0	130.14	.....	273.51	120.55	.....	259.22
14.0	111.58	.....	234.50	102.99	.....	221.46
15.0	95.67	.....	201.06	87.99	.....	189.20
16.0	82.03	.....	172.40	75.18	.....	161.66
17.0	70.34	.....	147.83	64.24	.....	138.13
18.0	60.32	.....	126.77	54.89	.....	118.03
19.0	51.73	.....	108.72	46.91	.....	100.87
20.0	44.37	.....	93.25	40.09	.....	86.20
21.0	38.05	.....	79.97	34.26	.....	73.67
22.0	32.64	.....	68.60	29.28	.....	62.96
23.0	27.99	.....	58.82	25.02	.....	53.80
24.0	24.01	.....	50.46	21.39	.....	45.99
25.0	20.60	.....	43.29	18.28	.....	39.31
26.0	17.67	.....	37.14	15.63	.....	33.61
27.0	15.16	.....	31.86	13.36	.....	28.73
28.0	13.01	.....	27.34	11.42	.....	24.56
29.0	11.16	.....	23.45	9.77	.....	21.01
30.0	9.58	.....	20.13	8.35	.....	17.95
31.0	8.22	.....	17.28	7.14	.....	15.35
32.0	7.05	.....	14.82	6.10	.....	13.12
33.0	6.05	.....	12.72	5.22	.....	11.24
34.0	5.19	.....	10.91	4.46	.....	9.59
35.0	4.46	.....	9.37	3.82	.....	8.21
36.0	3.83	.....	8.05	3.27	.....	7.03
37.0	3.28	.....	6.89	2.79	.....	6.00
38.0	2.82	.....	5.93	2.39	.....	5.14
39.0	2.42	.....	5.09	2.04	.....	4.39
40.0	2.08	.....	4.37	1.75	.....	3.76

[1] Normal for the season.

THE MINIMUM TEMPERATURE AT THE BASE OF THE STRATOSPHERE.

By W. J. HUMPHREYS.

One of the surprises that has come from sounding-balloon data is the evidence of a minimum temperature in the lower portion of the stratosphere. It has been thought that this recorded minimum is not real—not indeed in the air—but merely the effect of an instrumental error due to the gradual insolational warming of the thermograph under insufficient ventilation. Some records undoubtedly have been seriously affected in this manner, and it may well be conceded that none obtained in full sunshine is wholly free from temperature errors. Nevertheless, such errors are not sufficient to account in full, nor even in large part, for the decided temperature minima often recorded at and next above the base of the stratosphere.

If, however, it be affirmed that the vertical temperature distribution in this region is substantially as shown, which the accumulated records, including night records, require, then the obligation is thereby assumed of explaining how it is possible for a layer of air to be, so much of the time, colder than the atmosphere either above it or below. Such a layer certainly could neither be established nor maintained in a medium so nearly homogeneous in composition as the atmosphere by any known process of radiation or absorption. The explanation, therefore, of this minimum temperature, must be sought in some dynamical process. Nor, indeed, is it far to seek, for its nature appears to be indicated by the fact that the minimum temperature in question is essentially a phenomenon of the anticyclone, as is clearly shown in figures 2 and 3 of the article in this REVIEW, pages 159 and 160, on "Temperatures, pressures, and densities of the atmosphere at different levels in the region of northeastern France."

Now, whatever the origin of the anticyclone, one of its essential features is an extensive movement of air from higher latitudes toward lower. This air, therefore, because of the rotation of the earth, loses more or less of such eastward component of its velocity as it may have had. Hence it lags in its west-to-east flow and thereby acts as a partial barrier to the westerlies. These latter, in rising over this barrier, attain unwonted heights and consequently the topmost layers cool dynamically to temperatures below that which would put them in thermal equilibrium with the outgoing radiation; that is, below the normal temperature of the stratosphere. As such air runs forward it must produce at least three effects: (*a*) It must load that portion of the atmosphere over which it flows, and thus produce high pressure, with descending and dynamically warmed air below; (*b*) it must, in some measure, lift and, thus, through the consequent pressure readjustment, dynamically cool the stratosphere; and (*c*) it must establish, and in part itself constitute, a layer of minimum temperature at the bottom of the stratosphere. An exactly similar effect may also be produced, in some cases, by air on the forward side of a cyclone, as a result of its increased eastward velocity induced by its travel to higher latitudes.

This abnormally cold layer obviously is soon warmed to some extent by radiation, but as the intervals between anticyclones generally are only a few days, it follows that the lower portion of the stratosphere usually is colder than is the atmosphere either next above or below—colder because of endless repetitions at short intervals of dynamic expansions that always chill the topmost overflow beyond the limits of thermal equilibrium.

WHY THERE ARE NO CLOUDS IN THE STRATOSPHERE.

By W. J. HUMPHREYS.

The very frequent occurrence of cirrus clouds at and immediately below the base of the stratosphere makes it certain that during much of the time the atmosphere at this level is fully saturated. One might, therefore, suppose that the stratosphere, even if wholly devoid of vertical convection, would eventually also become saturated through long-continued diffusion. But the temperature of at least the lower portion of this region often drops 10° C., or more, with no evidence whatever of the formation in it of even a slight haze. Hence it would seem (*a*) that the stratosphere is so nearly devoid of condensation nuclei that it can become two to three fold supersaturated without appreciable condensation; or (*b*) that the difference between the amounts of water vapor that would produce saturation at the temperatures before and after cooling, −55° C. and −65° C., respectively, say, is not sufficient to produce a noticeable haze; or (*c*) that the assumption that the stratosphere is even approximately saturated is in error.

It will be convenient to consider these alternatives in the order given.

The idea that the absence of clouds in the stratosphere may be owing to the lack of condensation nuclei appears to be rendered untenable by the fact that in addition to the cosmic, or meteoric, dust always present, it occasionally contains also vast quantities of volcanic dust, and that even at such times it develops no clouds.

To test the second of the above alternatives—that is, whether or not the supposed condensation would produce a perceptible cloud—it is necessary to consider the effect of the possible amount of condensed water vapor on visibility. Let the initial temperature of the stratosphere be −55° C. and let it be temporarily cooled to −65° C., a supposition in approximate accord with actual occurrences. At −55° C. saturation pressure (expressed in terms of the height of a balancing column of mercury) is 0.0153 millimeter. At −65° C. it is 0.0038 millimeter, and the corresponding amounts of water vapor per cubic meter 0.02028 gram and 0.00528 gram, respectively. Hence on cooling from the higher to the lower of these temperatures there should appear (allowing for temperature contraction of volume) 0.01525 gram of ice crystals per cubic meter. Now it has been found [1] that, roughly, 0.3 gram of fog particles per cubic meter limits vision to about 90 meters. If, then, the ice crystals were the same size as the fog particles referred to the above computed quantity should limit vision to less than 2 kilometers. But it is also known that ice crystals formed at such low temperatures generally are much smaller than the average fog droplet, and therefore a decidedly more restricted vision should be anticipated. At any rate, it appears quite certain that if the strato-

[1] Wagner, Sitz. der K. Akad. der Wis. Wien, 117, p. 1290, 1908.

sphere were saturated at −55° C., approximately its average temperature in middle latitudes, any considerable lowering of its temperature, such as often occurs, would produce in it a decided haze, or cloud, such as, in fact, never appears in that region.

Clearly, therefore, clouds do not form in the stratosphere for the simple and sufficient reason that its relative humidity is very low. But this answer raises the further query: Why is this region so very dry and how is it kept so?

As there obviously is little or no vertical convection in the stratosphere it follows that each of its gaseous constituents must be distributed substantially as it would be if it alone were present. Assume, then, that this region begins at 11 kilometers above sea level, and that its temperature is −55° C. Furthermore, let there be saturation at and immediately below its base. Under these assumed conditions what would be the state of humidity of the stratosphere?

As stated above, saturation pressure at −55° C. is 0.0153 millimeter. Hence, assuming the temperature of the stratosphere to be the same throughout, it follows, from the hypsometric equation, that, under the action of gravity, the pressure of the vapor, to which, at constant temperature, its density is directly proportional, must decrease with elevation substantially as indicated by the broken-line curve of figure 1. That is, even under the above-assumed favorable conditions, the action of gravity would, of itself, prevent the stratosphere from becoming saturated—the maximum possible amounts of vapor at different elevations being those indicated by the curve just referred to.

But suppose this maximum humidity of the stratosphere should be attained, what would be the effect of cooling it 10° C., say, a drop in temperature that often occurs through at least its lowest several kilometers? To answer this question saturation pressures at different temperatures have also been given in figure 1. These are marked by dots, which, over the range taken, and for the indicated equal spacing of a constant temperature difference, fall, as shown, nearly along the curve of gravity distribution of vapor pressure. A mere inspection of this diagram shows, on the basis of the calculation made above, that under the assumed conditions the stratosphere would develop a dense haze. Hence, the actual humidity of this region must be far less than even the very limited amount possible under the restriction of gravity.

As is well known, during the passage of an anticyclone the lower portion of the stratosphere generally is considerably cooled. At each such time, therefore, all vapor that might be present in excess of that necessary to produce saturation at the current reduced temperature would be condensed out in the form of ice spicules that would slowly sift down. A sufficient subsequent increase of temperature, such as is also of frequent occurrence, would lead to the re-evaporation of these ice crystals and permit further diffusion of water vapor into the stratosphere from lower levels. But the next (never long delayed) drop in temperature would again precipitate the excess moisture, and so on indefinitely. And as the falling of ice crystals, though slow, is more rapid than the diffusion of water vapor, it follows that the stratosphere, even if initially fully saturated, would soon become excessively dry, soon attain and then indefinitely maintain a vapor

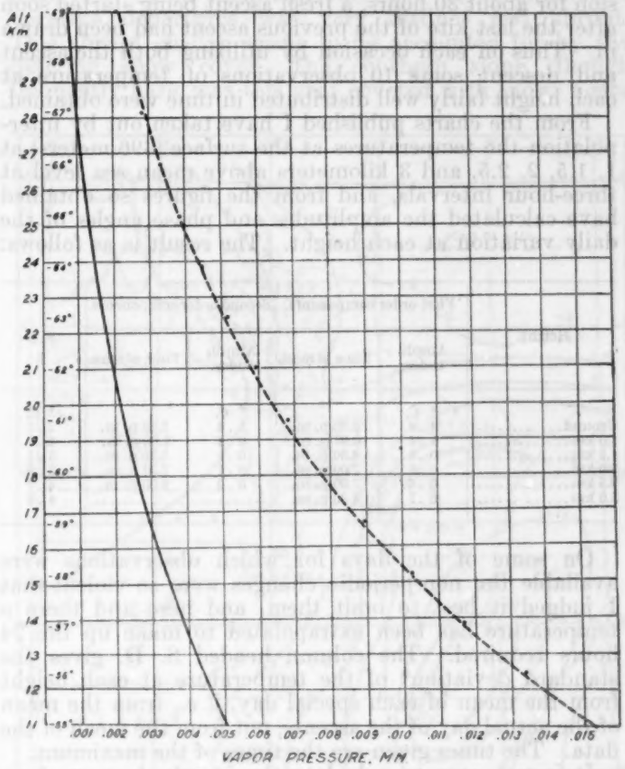

FIG. 1.—Gravity distribution of water vapor at constant temperature.

distribution more or less closely that indicated by the full line curve of figure 1, corresponding to a temperature of the stratosphere of −63° C.

It appears, therefore, that the clear, deep blue skies, typical of anticyclones, are owing to the extremely low humidity of the stratosphere; a condition maintained by the "cold waves" of this region that occur so frequently that there can never be any appreciable accumulation in it of vapor beyond that of saturation at even below the average of these minimum temperatures.

THE DAILY VARIATION OF TEMPERATURE IN THE LOWER STRATA OF THE ATMOSPHERE.

By W. H. DINES.

[Reprinted from Quart. Journ. Roy. Meteorological Soc., Jan., 1919, p. 41.]

In the supplements Nos. 10, 11, and 12 of the MONTHLY WEATHER REVIEW[1] a series of consecutive observations made with kites at Drexel, Nebr., is published. The observations were made by sending up kites in succession for about 30 hours, a fresh ascent being started soon after the last kite of the previous ascent had been drawn in. Thus on each occasion by utilizing both the ascent and descent some 10 observations of temperature at each height fairly well distributed in time were obtained.

From the charts published I have taken out by interpolation the temperatures at the surface (396 meters) at 1, 1.5, 2, 2.5, and 3 kilometers above mean sea level at three-hour intervals, and from the figures so obtained have calculated the amplitudes and phase angles of the daily variation at each height. The result is as follows:

Height.	First order components.		Second order components.		S. D.
	Amplitudes.	Time of max.	Amplitudes.	Time of max.	
	° C.		° C.		° C.
Ground	4.9	3.30 p. m.	1.3	1.30 p. m.	2.5
1.0 km	1.1	6.00 p. m.	0.4	7.00 p. m.	2.7
1.5 km	0.8	8.30 p. m.	0.1	5.30 p. m.	3.1
2.0 km	0.6	7.00 p. m.	0.1	7.00 p. m.	3.9
2.5 km	0.6	7.00 p. m.	0.2	8.00 p. m.	4.7
3.0 km	0.7	4.30 p. m.	.....	.....	4.9

On some of the days for which observations were available the non-periodic changes were so violent that I judged it best to omit them, and here and there a temperature has been extrapolated to make up the 24 hours required. The column headed S. D. gives the standard deviation* of the temperature at each height from the mean of each special day, i. e., from the mean of the actual day of the ascents, not from the mean of the data. The times given are the times of the maximum.

It is not easy to calculate the standard error of an amplitude, because the standard deviation of the observations is compounded of the casual deviation, the periodic change, and the non-periodic change, and this latter is large, reaching on the average about 5°C.; however, it seems plain that the casual error can hardly exceed 0.15, and hence that there is a genuine daily variation up to at least 10,000 feet with a maximum in the afternoon or early evening, and a range of about 2°F. In the second-order, or 12-hour, terms the amplitudes may well be casual, but the theoretical value of the casual error is the same for terms of all orders, and these amplitudes being of the same order as their casual error support the genuineness of the 24-hour terms which are four times as large.

Since Drexel is nearly 0.5 kilometers above mean sea level and is not on an isolated hill, the values given for the lower heights must not be taken as valid for places of small elevation. How far 3 kilometers over Drexel may be equivalent to 3 kilometers over a place at mean sea level is an open question.

[1] Washington, D. C., U. S. Dept. Agric., MONTHLY WEATHER REVIEW, SUPPL. 10-12, 1918.

*See MONTHLY WEATHER REVIEW, 1916, 44:510-512.—EDIT.

ON THE DIURNAL INCIDENCE OF MAXIMUM AND MINIMUM TEMPERATURES AT ESKDALEMUIR.

By A. CRICHTON MITCHELL.

[Abstract from Jour. of the Scottish Meteorological Soc., vol. 17, 1917, pp. 156-165, 6 diagr.]

In connection with certain inquiries it became necessary to obtain data as to the manner in which the frequency of occurrence of maximum and minimum temperatures is distributed throughout the twenty-four hours of the day. For this purpose the Eskdalemuir records for the six years 1911–1916 were immediately available. The times of occurrence of maximum and minimum temperatures were tabulated by hours and months. From these tables, graphs were constructed showing the mean times of maximum and minimum temperature, the standard deviations, and the mean recorded sunshine by months and by years, also the total frequency of maximum and minimum temperatures in summer and winter.

As is to be expected, the times of maximum and minimum show the least deviation from the mean in summer, when solar heating dominates the weather, and the greatest in winter. For the maximum temperatures, the mean for the summer half year lies almost exactly at 2 p. m., and the standard deviation is 2.55; and for the winter the mean is an hour earlier, and the standard deviation, 5.85, more than double that for summer. For the minimum temperatures the corresponding figures are: Summer, 1:45 a. m., 2.79; winter, 1:30 a. m., 4.29. The hours of greatest frequency of maximum temperature are 1–2 p. m. in January, February, April, October, November, and December; 2–3 p. m. in March, May, June, and August; and 3–4 p. m. in July and September. It is an interesting commentary on the winter climate in Scotland that in January the frequency of maximum temperatures is almost as great from midnight to 1 a. m. as from 1 to 2 p. m., although it sinks to zero in mid a. m. and p. m. In order of frequency, 11 p. m. to midnight ranks third and 2 to 3 p. m. fourth in the 24 hours. In December the order of frequency is (1) 1–2 p. m., (2) mt.–1 a. m., and (3) 11 p. m. to mt. The hour of greatest frequency of minimum temperature is 11 p. m. to midnight in all months except December, when it is from midnight to 1 a. m. Secondary peaks of frequency of minimum temperatures range from 8–9 a. m. in December and January to 3–4 a. m. in June. Considering the cloudiness data, on the average, an increase of one-tenth in the amount of unclouded sky during the later hours of the day is accompanied by a postponement of the time of minimum temperature by about 40 minutes.—*C. F. B.*

INFLUENCE OF SNOW COVER ON THE TEMPERATURE DISTRIBUTION IN UTAH, JANUARY, 1919.

THOMAS ARTHUR BLAIR, Meteorologist.

[Dated: Weather Bureau Office, Salt Lake City, Utah, Mar. 1, 1919.]

The January [1919] distribution of temperatures in Utah offers some unusual features which seem to be worthy of special notice, since they appear to illustrate a relation between snow cover and air temperature. Most of the northern part of the State, which was practically bare of snow throughout the month, had a January mean temperature above normal. The departures were especially marked along the extreme northeastern counties, adjoining Wyoming. This part of the State is separated from the remainder by two mountain ridges, namely, the northern spurs of the Wasatch Mountains, running north and south, and the Uinta Mountains, trending almost due east and west, with a general elevation of about 12,000 feet, one of the most important latitudinal ridges in the country. In previous years, the high and comparatively small valleys north and east of these ridges have always been covered with snow in January, so far as our records show, but this year they were bare, owing to the almost total lack of precipitation in December and January; and here two stations show temperature departures of more than 7° above normal. South of the Uintas is the semi-arid region drained by the Green and Colorado Rivers, a region which is frequently bare during much of the winter, but which this year had an unusually heavy snowfall in December, which remained on the ground throughout January. Here the temperature departures were all negative, some stations showing the coldest month of record. It was more than 18° below normal in eastern Emery and Wayne Counties, with surrounding stations from 6° to 9° below. These subnormal temperatures extended into the southwestern desert region of Millard, Beaver, and Iron Counties, which were not continuously snow covered, but the extreme southwestern counties, which were bare, were above normal. North of the Uintas, the station at Manila shows a departure of +7.3°, while 50 miles south on the southern slope, Fort Duchesne had a departure of —6.1°, and 70 miles southwest, Duchesne's departure was —9.6°, a difference of 16.9° as compared with the normals. Isograms of the temperature departures are drawn on the accompanying chart, (fig. 1), and the depth of snow on the ground at the end of the month is entered at the locations where observed.

This temperature distribution seems to present an excellent example of the influence of the snow-covered ground, frequently noted by students of forecasting,[1] in building up and retarding the Great Basin highs, which are a marked feature of winter conditions over the Plateau States. During January these highs were especially persistent over the snow-covered area of southeastern Utah and western Colorado, as shown by the daily reports from Grand Junction and Durango. On some occasions a small high area lingered for several days over this region, as shown by the weather maps of the 8th to 10th, inclusive, and the 15th to 19th, inclusive; while on other occasions, notably the 4th, 8th, 18th, and 28th, there was a small secondary high, seemingly the direct result of radiation.[2]

Larger causes resulted in a warm January in the States north and east of Utah, with the center of greatest departure in northeastern Montana, but the departures along the Utah-Wyoming border were greater than those farther north and east and the line of demarkation along the Uinta Mountains between the positive and negative departures was very distinct and abrupt. This abrupt change seems to be accounted for by the differing snow cover. The southern slope, though frequently bare, was this year covered with snow; hence

FIG. 1.—Isograms of temperature departures, and snow on the ground at end of month, Utah, January, 1919.

there was less than the usual warming by day and much more than the usual cooling of the air by night in the almost continuously clear weather, for this was the driest and clearest January of record in this region, with an average of but three cloudy days. But the northern slope, though generally snow-covered, was this year bare, and hence received more warming and less cooling than under average conditions. That the changes in night radiation during winter resulting from a snow cover or its absence are greater than those of daytime heating is indicated by the following table, showing

[1] Weather Forecasting in The United States, Washington, 1916: Henry, A. J., p. 133; Brandenburg, F. H., p. 322.

[2] On account of reductions to sea level, only the stronger highs shown on weather maps in the plateau States during cold winter weather, are truly anticyclones.—EDITOR.

that the departures of the mean minimum were greater in most cases than those of the mean maximum on both the north and south slopes.

Departures of the mean maximum and the mean minimum from the normal at stations in eastern Utah during January, 1919.

[The first three stations are north of the divide; the others south.]

Station.	Snow on ground at end of month.	Mean maximum. °F.	Mean minimum. °F.
Laketown	0.5 in.	+ 2.1	+ 7.2
Manila	0	+ 6.9	+ 7.6
Woodruff	0	+13.2	+ 1.9
Blanding	7.0	− 8.7	− 9.4
Castle Dale	.....	− 7.2	− 5.9
Duchesne	4.0	− 6.9	−13.5
Escalante	12.0	− 6.6	−10.8
Fort Duchesne	2.0	− 4.3	− 7.5
Green River	.....	−16.5	−21.4
Hanksville	9.0	−21.2	−21.9

Possibly a chinook effect, for which the pressure distribution was favorable, was in part responsible for the high temperatures along the northern and eastern slopes of these ridges, though no decided chinook conditions are discernible in the daily temperatures. The idea is strengthened, however, by the fact that the departures were greater here than at some distance from the divide in southwestern Wyoming, which was also generally bare of snow. But this region, like southeastern Utah, is bare with sufficient frequency to have raised the normals, and it is believed that we have in the temperature distribution described above principally an illustration of the importance of snow cover in influencing local temperatures.*

*For other recent discussions of the influence of snow-cover on air temperature, see Mo. Wea. Rev. 1917, 45: 272; and 1918, 46: 570–580.—EDITOR.

THE EFFECT OF GUNFIRE ON THE RAINFALL OF THE BRITISH ISLES.

[Abstract reprinted from Geographical Review (New York), January, 1919, p. 51.]

A recent statement from Dr. H. R. Mill, director of the British Rainfall Organization, the leading authority on rainfall in the British Isles, gives an answer, as definite as is possible, to the much-discussed question of the effect of the gunfire in Europe upon the amount of precipitation in Great Britain (Symons's Meteorol. Mag., February, 1918). Two districts are selected, southeastern England, which was nearest to, and the northwestern district (comprising stations from Sutherland and the Hebrides to the west coast of Ireland), which was farthest from, the scene of the firing in Flanders. The monthly rainfalls from 1909 to 1917 are summarized in percentages of the average. In the period before the war there were 14 dry or very dry months in southeastern England and 12 wet or very wet months. During the war there were 12 dry or very dry and 13 wet or very wet months. A single month transferred from one category to the other would bring about an equality or even a reversal. In the northwest, in the same two periods, very dry months were equally numerous, and there were no very wet months. Taking dry and very dry months together, there were 7 before and 14 during the war, and of wet months there were 14 before and 15 during the war. Dr. Mill points out that much emphasis has been laid on the relative wetness of the years 1915 and 1916 in southeastern England, but this record should be considered in connection with the fact that the year 1917, when the war was in a very intense phase, had a nearly normal rainfall.—R. DE C. WARD.

FIG. 2.—Looking east across the path of the storm. Roof of Negro Baptist Church, all that remained of the building.

FIG. 3.—Home of C. B. Harris (center) and a few other buildings left standing east of the path of the storm. Looking east across the storm's path.

TORNADO AT PORTER, OKLAHOMA, MARCH 15, 1919.

By J. A. REIHLE.

[Dated Aerological Station, Broken Arrow, Okla., Mar. 25, 1919.]

On March 15, 1919, at 4:07 p. m., a tornado struck Porter, Okla., a town of 800 population in the northeast part of the State, 12 miles northwest of Muskogee, leaving complete destruction in a narrow path across the town. The path of the storm was from southwest to northeast, as shown by the accompanying map, figure 1; its width was about 200 feet and its length inside the town one-fourth mile.

The day was warm; intermittent showers prevailed throughout the afternoon, and the sun shone for a brief period 15 minutes before the storm broke. At Broken Arrow Aerological Station, 25 miles northwest of Porter, a pilot balloon flight was made at 3 p. m., which shows that the wind was from the south, and varied in velocity from 14 meters per second at the surface to 25 meters per second (56 miles per hour) at 500 and 750 meters aloft.

A black funnel cloud was seen approaching from the southwest or south-southwest. The funnel zigzagged back and forth as it approached, sometimes touching and again receding from the earth. The roar was heard for two or three minutes before the storm reached the town; the noise of its passing was likened to an explosion. It was accompanied by lightning and thunder and a heavy downpour of rain lasting five minutes.

There is undoubted evidence of a counterclockwise whirl. However, there is no sign of a retrograde motion of the air on the left side, as shown by débris, trees, and poles; these lean inward nearly at right angles to the direction of the path of the storm, while trees and poles on the right side are bent forward almost parallel with the path of the storm.

The storm did not pass through the center of town, but along the edge, which was mostly a thickly settled Negro district. Two persons, both Negroes, were killed and a score or more injured by flying débris. The property loss is estimated at $200,000. A cotton gin, the Missouri, Kansas & Texas Railway depot, six business houses, 25 cottages, a church and schoolhouse were destroyed. Six horses and several dogs were killed, and the ground was literally strewn with fowls.

The first buildings demolished were those at the cotton gin of Mr. C. C. Hultquist (Nos. 1, 2, 3, fig. 1). Nothing was left of the seed house, No. 1, while the storage house, No. 3, was only slightly damaged. Corrugated iron used in these buildings was scattered across town and for a mile or more over the country to the northeast.

Both ends of the Missouri, Kansas & Texas passenger and freight depot were blown out, and a box car standing on the siding on the south side was overturned against the building. It was nearly train time and the waiting room was filled with people. Among these was a party of teachers and pupils who had been attending a school contest at the place. When the walls were carried away these people, as well as the ticket agent, were sprayed with pieces of brick and mortar, but none was seriously injured.

Just across the Missouri, Kansas & Texas tracks along Main Street begins the business section of the town, with a solid row of buildings on the west side of the street. The first building was a frame structure housing the gas distributing station. The building (No. 6) was entirely removed, the meters carried away, and one of the gas pipes supplying the stricken area was twisted and closed, thus averting a fire which might otherwise have followed. Nos. 7, 8, and 9 were, respectively, general store of Mr. Henry Allen, garage, and restaurant of Mr. Hays. All three buildings were gutted, the front and back walls being torn out and a heavy beam binding the three buildings together across the front was removed and carried across the street. Messrs. Allen and Hays were in their respective places of business, but neither was seriously hurt. Farther down Main Street several plate glass windows were broken by the explosive action of the air, and brick walls were damaged by heavy bodies thrown outside the vortex of the storm.

In the second and third blocks after leaving the intersection of Main Street and the railroad the storm wiped

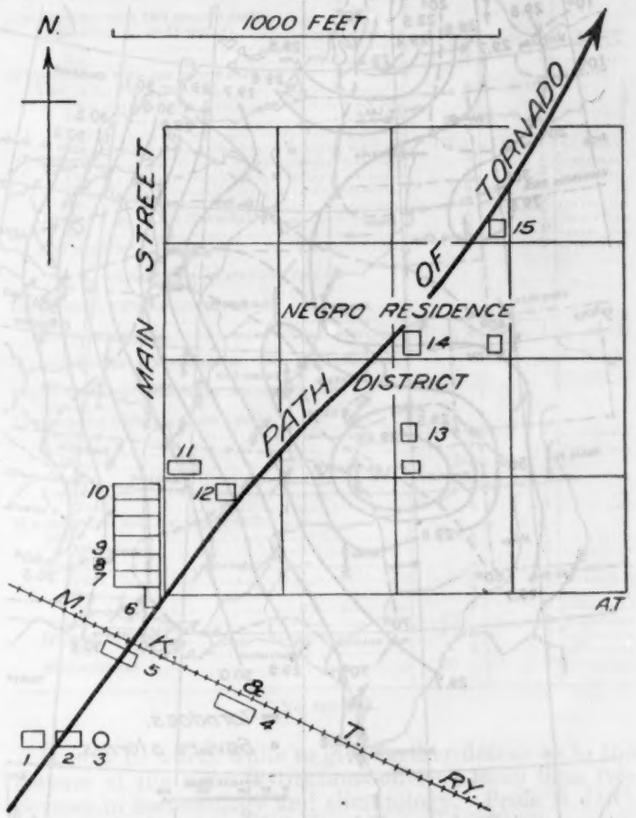

FIG. 1.—Map showing path of tornado through Porter, Okla.
1, 2, 3. Seed, power, and storage houses of C. C. Hultquist's cotton gin.
4. Bowers and Brown elevator.
5. Missouri, Kansas & Texas passenger and freight depot.
6. Gas-distributing station.
7. General store of Mr. Henry Allen.
8. Garage.
9. Restaurant.
10. First National Bank.
11. Dunlap store.
12. Blacksmith shop.
13. Residence of Mr. C. B. Harris.
14. Negro Baptist Church.
15. Negro schoolhouse.

out nearly all the houses in the Negro district. Some 25 houses were demolished, and it seems miraculous that the occupants, many of whom were in the houses at the time, escaped alive. In a number of cases it is seen that the walls burst outward, the roof lying flat on the ground and the ceiling lying on it, both intact and upside down.

Nos. 12, 14, and 15 were, respectively, blacksmith shop, Negro Baptist Church, and Negro schoolhouse, all destroyed. The framework of the roof of the church was deposited about 75 feet north of where the church had stood (see fig. 2).

East of the path of the storm stand a few scattered buildings undamaged except that the windows were

blown out. Of these, No. 13 is the home Mr. of C. B. Harris (see fig. 3), who made his way out of the storm's path and into his house just in time to escape. No. 4 is an elevator. This tall building standing so near the path of the storm and remaining undamaged shows that destructive velocities did not extend appreciably farther from the center at an altitude of 50 to 75 feet than at the ground.

Some freaks of the wind were reported. A farmer who had just left the store, started across the street when he saw the storm coming. Finding nothing else to hold to he clutched the wheel of a wagon near the curb. The wind struck and for a brief flash the man wrestled with the wagon. Then it broke from him and went flying

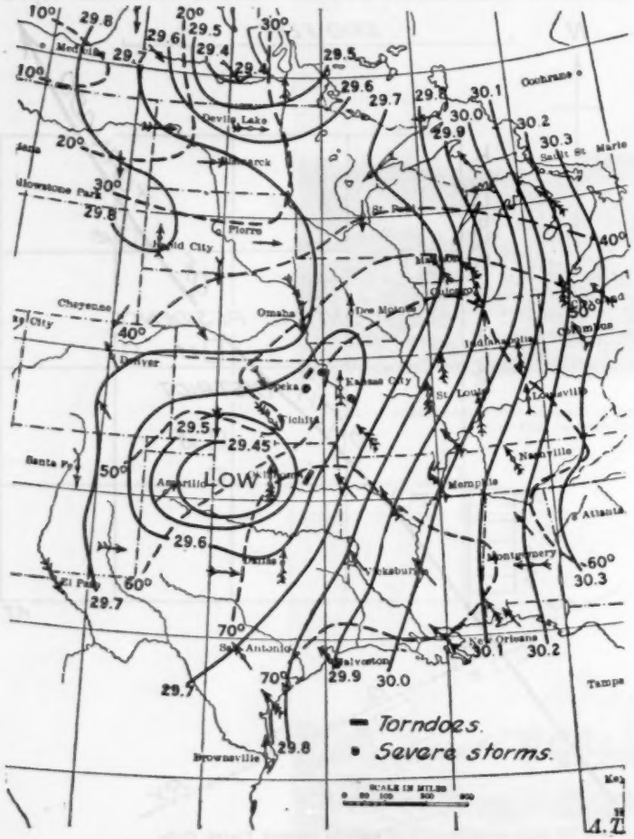

FIG. 4.—Weather map, Mar. 15, 1915, 7 p. m., 90th meridian time. Number of barbs on wind arrows indicates velocities in Beaufort scale.

away in the air. The farmer was not injured. Near the railroad station four teams of horses were tied. The tornado dipped over the first team and lifted the second and fourth. The first and third teams were unharmed.

Leaving Porter the storm continued in a northeasterly direction, depositing débris picked up in Porter along its path for several miles. Two schoolhouses and some farm buildings were destroyed in the next 4 or 5 miles.

DISCUSSION.

The tornado described was one of many severe storms accompanying a cyclone central over the Great Plains on March 15. Some of these are briefly described in the accompanying account taken from the Tulsa (Okla.) Daily World, March 16, 1919:

KANSAS CITY, MO., *March 15.*

Three persons are reported as killed, scores injured, and a vast amount of property damaged by tornadoes and cloudbursts, which struck towns in Kansas, Missouri, and Oklahoma late this afternoon.

The town of Porter, Okla., 12 miles northwest of Muskogee, was struck by a tornado which laid waste most of the business section. Three people are thought to have been killed and many injured. The place is said to be a pile of wreckage. A 48-mile wind was reported from Oklahoma City.

At Atchison, Kans., a cloudburst in which 3 inches of water fell within an hour, filled the streets, flooded basements and caused damage estimated at $100,000.

A heavy windstorm which swept through Clinton, Mo., unroofed many houses in the residence section and blew railroad cars from the track. Telephone and telegraph wires are down.

Sweeping through northern Jackson and western Atchison counties in Kansas, a tornado wrecked a score of farmhouses, and injured a number of people. Buildings on two blocks in the town of Muscotah were destroyed. A heavy rain followed the wind here.

All rainfall records for the month of March were broken at Topeka when a precipitation of 3.88 inches was recorded. Small streams entering the Kaw are expected to go out of their banks before morning. Reports received from western Kansas indicate that a heavy rainfall was general throughout the Kaw Valley. Hail was reported in a few places.

The weather map of the evening of March 15 (about 6:15 p. m. local time) is reproduced as figure 4. At this time, two hours after the occurrence of the tornado, there was a northwest wind of 36 miles an hour and a temperature of 48° F. at Wichita, following a maximum velocity of 88 miles an hour, while at Oklahoma City there was a strong south wind of 36 miles an hour and a temperature of 70° F. It seems probable that some of the cold wind which was blowing at the surface in central and western Kansas overran the strong warm wind in eastern Oklahoma, and by the highly unstable and turbulent condition thereby produced caused the whirl at Porter and the excessively strong convection which made the intense storms at many other points in this region.—*C. F. Brooks.*

THE STORM OF MARCH 16, 1919, AT FORT SMITH, ARK.

By LEON J. GUTHRIE, Meteorologist.

A destructive thunderstorm, attended by violent wind gusts of 76 or more miles an hour, occurred a few minutes after midnight of March 15.

Lightning was observed to the west and southwest of the station about 10:30 p. m. of the 15th. Thunder began at 11:38 p. m. and continued at intervals until 1:33 a. m. of the 16th. At 12:07 a. m. the wind attained an extreme of 76 miles an hour and a 5-minute maximum of 58 miles an hour; but it blew in violent gusts that probably momentarily exceeded these figures, especially at points about 1 mile north of the Weather Bureau station. The storm moved from the southwest to the northeast, the path of greatest violence roughly following the banks of the Arkansas River, through the northern part of the city, thence through Van Buren and to Alma. The path was about 1 mile wide in Fort Smith, but had narrowed to about a half mile when it passed through Van Buren. The storm showed none of the characteristics of tornadic action, and its attendant display of lightning and thunder was extremely mild.

In the northern part of Fort Smith and in Van Buren the damage to roofs, windows, chimneys, wires, truck crops, and small frail buildings totaled in the neighborhood of $25,000.

The greatest loss was suffered by the Berry-Beall Dry Goods Co., a wholesale house, whose entire stock, valued at $500,000, was materially damaged. The roof of the store was blown off, and the pipes connecting the building with a large water tank were broken. The contents of the tank were emptied into the building from the top floor, drenching the entire stock.

The damage to the dry goods was approximately $200,000, making a total loss of $225,000 caused by the storm. Two persons are known to have suffered slight injuries, but there was no loss of life.

GENERAL EXTENT OF COLLEGIATE INSTRUCTION IN METEOROLOGY AND CLIMATOLOGY IN THE UNITED STATES.

By CHARLES F. BROOKS, Meteorologist.

[Dated: Weather Bureau, Washington, D. C., Apr. 29, 1919.]

On February 24, 1919, Commissioner P. P. Claxton, of the Bureau of Education, sent the following circular to the presidents of colleges and universities in the United States:[1]

The Weather Bureau of the United States Department of Agriculture desires this office to obtain information concerning the extent of instruction in meteorology and climatology at higher institutions. May I ask you, therefore, to reply to the following questions at your convenience:

(1) Name of institution.
(2) Post-office address.
(3) Name of reporting officer.
(4) List of courses now offered in meteorology and climatology with statement of time devoted to each course.

To date, 433 replies have been received, and judging from the large proportion of those reporting no courses it is thought that the lack of replies from the other 200 is largely a result of no courses being offered. Of the 433 replying, 363 institutions reported that no separate courses in meteorology and climatology were given. Of these 363, 83 mentioned that some instruction in meteorology was given in more general courses, and 49 others stated, or let be assumed from their replies, that meteorology had been taught separately at the institution or would be soon; 10 institutions mentioned Weather Bureau officials as the instructors. Tables 1 and 2 indicate in some detail the nature of the replies.

TABLE 1.

I. Institutions giving meteorological courses	70
Departmental affiliation—	
Geology	20
Physics	10
Chemistry	1
Biology	1
Astronomy	1
Not specified	37
II. Institutions giving no meteorological courses	363
A. Meteorology or climatology taught in other courses	83
Geology and geography	34
Geology and astronomy	9
Geology and physics	4
Geology, physics, and astronomy	1
Geology and agriculture	1
Physics	13
Physics and astronomy	2
Agriculture	6
General science	4
Not specified	9
B. No present instruction mentioned	280
Course planned for next year	2
Want to teach subject	13
Past instruction implied without reference to future	34
Other institutions without meteorological instruction (8 mentioned having observing stations)	231

Of the institutions giving courses in meteorology and climatology, a quarter give the equivalent of a full year or more of instruction, with three class-room meetings a week; one-half give the equivalent of one to two semesters' meteorological course; and a quarter give less than a semester's three-hour course. Less than half mention any kind of laboratory work.

[1] Total number, about 650, of which about a fifth are junior colleges.

TABLE 2.—*Nature of meteorological courses given.*

Duration.	Class-room hours per week, not including laboratory.	Institutions. Number.	Institutions. (Doubtful classification).
I. COURSES IN METEOROLOGY ONLY.			
3 institutions with two courses each:			
Semester (i. e., 16–18 weeks)	3	1	.....
Do	3–1	1	.....
Do	2	1	.....
37 institutions with one course each:			
Year (i. e., 8 or 9 months)	4	.....	1
Do	3	2	2
Do	2	.....	1
Do	1	1	1
Do	(1)	1	.....
Semester	5	1	.....
Do	4	2	.....
Do	3	12	1
Do	2	9	.....
Quarter (i. e., about 12 weeks)	5	1	.....
Do	3	1	.....
Half semester	(1)	2	.....
II. COURSES IN CLIMATOLOGY ONLY.			
2 institutions with one course only:			
Year	4	.....	1
Semester	3	1	.....
III. COURSES IN METEOROLOGY AND CLIMATOLOGY.			
8 institutions with more than two courses each: *See text.*			
7 institutions with two courses each:			
Semester	5	1	.....
Do	3	1	.....
Do	3–2	1	.....
Do	2	2	.....
Quarter	5	1	.....
Do	4	1	.....
13 institutions with one course each:			
Year	3 or 5	1	.....
Do	2	2	.....
Semester	5	1	.....
Do	3	2	.....
Do	2	1	.....
Do	1	2	.....
Do	(1)	1	.....
Quarter	3 or 5	1	.....
Do	3	1	.....
Half semester	(1)	1	.....

[1] Not specified.

It may be worth while to give further details as to the courses at the eight institutions offering more than two courses in meteorology and climatology. Profs. R. DeC. Ward and Alexander McAdie, of Harvard, offer six semester courses—two in meteorology and four in climatology; and the university offers credit for research work in meteorology and climatology also. During the present year but three of the six courses are being given. Radcliffe college offers 3 semester courses chosen from Harvard's six, all given by Prof. Ward, Cornell University, with Prof. W. M. Wilson in charge of meteorological instruction, offers five courses, each having one or two class-room meetings per week. Research credit is also given. Mr. Eric R. Miller, of the University of Wisconsin, offers two successive three-hour semester courses on weather and climate, and on climate and man; and, in alternate years, full courses in meteorology or climatology. Mr. B. M. Varney, at the University of California, gives a half course in meteorology followed by one in climatology; and offers more advanced instruction in a two-hour course on current developments in meteorology and climatology. Mr. G. A. Loveland, in the University of Nebraska, offers a two-hour course for the year and two one-hour courses for one semester each. He also gives a year's course in climatology, one hour per

week. In the University of North Dakota, Prof. H. E. Simpson presents a four-hour semester course in meteorology, and a two-hour course in climatology. Credit for research work is offered. Finally, in George Washington University, Prof. W. L. Moore gives a course on applied meteorology, and Prof. W. J. Humphreys one on meteorological physics. Prof. Humphreys's course is for advanced students only.

With relation to the position of meteorology and its outlook for further development, it is to be regretted that there are only three universities in the country where research in meteorology is specifically encouraged, and that even the semblance of a thorough course in elementary meteorology is given at only one in ten of the institutions of higher learning in the country. Surely, the weather is of sufficient interest and importance to deserve individual representation in the curricula of most colleges and universities. Let us hope that without being forced to it, more institutions will have the experience of Muhlenberg College. Prof. I. M. Wright says: "During the S. A. T. C. I had 60 men in the course in meteorology and the work made such an appeal to the men that we are continuing it in the regular college curriculum."

METEOROLOGICAL OBSERVATIONS WHILE TRAVELING.

By ROBERT DEC. WARD.

[Abstract: Handbook of Travel, Harvard Univ. Press, 1917, pp. 451-472.]

Weather conditions are such ever-present and obvious controls of all outdoor activities that no one, least of all a traveler, can be unconscious of them. By devoting a few minutes a day to recording simple observations, every traveler, whether skilled in meteorological work or not, may not only make his own journey more worth while, but also add something definite and valuable to our knowledge of the meteorology of little known regions. The traveler who has never made a study of meteorology and who wishes to gain some general knowledge of the subject before he starts on his journey, may well read over one of the newer American meteorological textbooks. If he desires to acquaint himself with the climatic conditions of the region which he plans to visit, he will do well to consult the standard work on local climate. In this he will find mention of important local phenomena which may be especially worthy of attention and further observation.

The present subject may be considered under two heads: (1) Non-instrumental, and (2) instrumental observations.

Non-instrumental observations.—Many travelers feel that unless they can keep up a complete series of standard meteorological records, with a considerable and superior instrumental equipment, it is not worth while to attempt any observations whatever. This is by no means the case. Even such irregular notes as may be made by a traveler on a train, on horseback, on foot, or on shipboard are often of real interest. A few careful non-instrumental observations, especially if made regularly, are often of more value, even to meteorologists, than any number of careless and inaccurate instrumental records. Even in the most elaborate meteorological records, many weather elements are always observed non-instrumentally.

The hours of observation preferably should be about 7 a. m., 2 p. m., and 9 p. m. to get a general summary of the character of a day. Temperature observations such as chilly, muggy, exhilarating, depressing, mild, excessively hot, etc., are well worth recording, as they give a human picture of the weather not easily obtainable from the other observations. Wind observations on the basis of the Beaufort scale and eight points of the compass are most satisfactory. Special winds such as mountain and valley breezes are worth particular mention. Cloud observations involve particularly the amount of cloudiness, the kinds and the directions from which the clouds move. The records can be made to show the tenths or thirds of the sky covered, the general thickness of the clouds, and particular features of the cloudiness best covered in a brief description. Non-instrumental rainfall observations may be made by describing the intensity of the falling rain; or, if the rainfall is not observed, by noting the condition of the countryside in general, especially as regards vegetation. All sorts of miscellaneous phenomena, when recorded, complete the weather record.

Instrumental observations.—The extent of his instrumental equipment will be determined by the interest, time, and means of each traveler. In the following sections reference is made only to the simple equipment which the average man will probably be able to take. Those who wish to give more time to this subject should consult the standard scientific guides for travelers and the instructions in the use of the various instruments, published by the United States Weather Bureau. Whatever be the equipment, care should be taken to secure good instruments. It is essential that the traveler should familiarize himself with their use before he starts on his journey.

The sling psychrometer is the most convenient type of thermometer and humidity instrument. Aneroid barometers are the most handy for pressure measurements, and will serve not only for local weather forecasting but also for altitude determination. A small rain-gauge may be carried and is frequently of considerable use, especially if travel is not performed on rainy days. Other instruments which may be taken with the traveler are barograph, pocket nephoscope, portable anemometer, and an instrument for determining the true direction and velocity of the wind at sea.

Two pages at the end of the chapter show where instruments may be obtained and their approximate prices, and give references to four textbooks, two scientific guide books, special instructions in the use of instruments, and meteorological tables.—C. F. B.

SOME ECONOMIC EFFECTS OF THE MILD WINTER, 1918–19.

A year ago so much was being written on the effects of the extremely severe winter of 1917–18 that it seems appropriate to make some mention of the economic effects of the extraordinarily mild winter of 1918–19 in the eastern United States.[1] It is unnecessary more than to mention the great saving of coal which resulted from the

[1] The meteorological conditions inducing this mild weather have been discussed in the MONTHLY WEATHER REVIEWS for the different months, and especially by E. H. Bowie, in the January, 1919, REVIEW, pp. 45–46, 2 plates.

mild weather; and the generally favorable effect on vegetation, especially the winter grains.[2] The saving in transportation costs, while very great, is not so generally realized because ice and snow interruptions to transportation and the destruction of perishable foodstuffs by cold weather are thought of as unfortunate occurrences. Thus the lack of these may be hardly noticed.

The following excerpts from an extended article "Millions saved on mild winter," published in the New York Times, April 6, 1919 (sec. 2, p. 2) give some of the details of the saving which resulted from uninterrupted traffic in a great metropolis and elsewhere:

"The money saving of a mild winter benefits the shippers, the wholesale and retail dealers, the truckmen, who are able to maintain good deliveries, and the householders, whose coal bills decreased.

"The winter of 1917–18 and that of 1918–19 were two extremes and for that reason the comparison shows a more pronounced saving. * * * New York City Street Cleaning Department records show that in the 1916–17 winter there were 46.2 inches of snow to contend with, and 7,879,824 cubic yards were removed at a cost of $1,127,018, while in the 1917–18 winter, although there were only 22 inches of snow and 5,902,910 cubic yards were removed, the cost of removal was $2,676,603. This was due to ice. * * *

"Snow removal with the railroads is not a local but a country-wide problem. When it is mild in one part of the country, in another the railroad men may be fighting drifts and meeting the handicap of frozen switches. Removing snow and ice in an ordinary winter costs between $5,000,000 and $6,000,000, and in the winter of 1917–18 it was perhaps $1,500,000 more. In the winter just ended the cost was far below the cost of an ordinary winter. A man connected with the traffic management of one of the big railroad companies estimated that a mild winter will show a saving of 25 per cent on the figures given, and in an extremely mild season, such as the winter just ended, there should be a saving of fully 50 per cent on the figures given. * * *

"In estimating the saving on an open winter, such as that just ended, there must be reckoned the saving that came to New York through the uninterrupted flow of freight in and out of this city.

" * * * * Coal that in 1917–18 came to the coal ports solidly frozen in the cars had to be steamed out, sometimes to freeze again before it could be dumped into barges, flowed out last winter as freely as it does in June, and there was no need of the elaborate steam sheds that had been added to the railroad equipment in anticipation of another hard winter and a continuation of the wartime demand."—C. F. B.

BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Alaska. Agricultural experiment station.
Report, 1917. Washington. 1919. 96 p. plates. tables. 23 cm. [Monthly precipitation and temperature for Fairbanks, 1911–1917, p. 59–60. Weather reports for 1917, p. 90–96.]

Alsace-Lorraine. Meteorologische Landesanstalt.
Deutsches meteorologisches Jahrbuch, 1908–1910; 1913–1914. Strassburg. 1916–1918. 5 v. tables. 32½ cm.

Angot, Alfred.
Instructions météorologiques. Sixième édition, revue et corrigée. Paris. 1918. vi, 183 p. illus. plates. tables. 24 cm.

Batavia. Magnetisch en meteorologisch observatorium.
Observations made at secondary stations in Netherlands, East India. Vol. 6 (1916). Batavia. 1918. ix, 97 p. incl. tables. 37 cm.

Bouches-du-Rhône. Commission de météorologie.
Bulletin annuel. Année 1917—36e année. Marseille. 1918. xii, 74, xxii p. map. charts (part. fold.). tables. 28 cm. [Mémoires, p. i–xxii at end of volume: Documents relatifs au climat de Marseille (1823–1917). Le problème de la météorologie agricole (Les idées du Docteur Girolamo Azzi).]

Club alpino italiano.
I pericoli delle valanghe di neve e norme per evitarli. 2a edizione, 1916. Pubblicazione autorizzata dal Comando Supremo. Torino. 1916. 15 p. 13 cm.

Colombo observatory.
Report on the Colombo observatory for the year 1916–17. 2 v. charts (part. fold.) tables. 34 cm. (Reprinted from the Ceylon blue book, 1916–17.)

Fontseré [y Riba], Eduard.
Sobre els vents estivals de convecció a la costa catalana. Barcelona. 1918. 63 [1] p. plates. illus. maps. charts. tables. 27 cm. (Publicacions de l'Institut de ciències.)

France. Service météorologique militaire.
Additif à la notice sur le fonctionnement des postes de sondages aérologiques. [Paris] 1918. cover-title, 32 p. incl. tables. 29 cm. At head of title: Ministère de la guerre. Service géographique de l'armée. Bureau météorologique militaire. [Rapid process for determining the velocity of the wind, 0 to 3,000 meters.]

Étude de la dépression secondaire du 7 janvier 1917. [Paris] 1917. cover-title, 10 [1] p. 31 cm. 5 fold. sheets of charts in pocket at back. At head of title: Ministère de la guerre. Service géographique de l'armée. Bureau météorologique.

Installation, lecture et entretien des instruments météorologiques. Paris. 1918. 54 p. illus. charts. tables. diagrs. 24 cm. At head of title: Publications scientifiques du Service géographique de l'armée.

Tables de dépouillement des sondages aérologiques, octobre 1918. Paris. 1919. 42 p. incl. tables. 26 cm. At head of title: Publications scientifiques du Service géographique de l'armée. Contents: 1. Tables des projections horizontales. 2. Tables de calcul du vent balistique.

Transmissions météorologiques par T. S. F. Code valable à partir du 1er Mars 1919. Paris. 1919. 4 p. 21½ cm.

Hankow. Griffith John college.
Meteorological survey for 1918: comp. from readings taken by the 1st Hankow troop of Chinese boy scouts. Hankow. 1919. cover-title, [18] p. incl. charts. 16½ by 21½ cm.

Italy. R. Esercito italiano. Sezione meteorologica.
Note pratiche sulle nebbie primaverili ed estive. [Roma. 1918] [2] p. 21½ cm.

Pubblicazione N. 4, 18, 22, 26–31. Roma. 1916–1918. 9 v. illus. plate. fold. maps. charts (part. fold.). tables (part. fold.). fold. diagrs. Size varies 14½–17½ cm. Contents: 4. Monte Nero o Krn. 18. Giulia e Carnia. Notizie sulla precipitazione nevosa e su alcuni punti soggetti a valanghe. 22. Le valanghe nelle Alpi venetotridentine. Nozioni pratiche sopra i pericoli, le precauzioni i presagi generali e locali, i salvataggi. 26. L'orizzonte di Padova. 27. Sistema difensive dalle valanghe. Grafico illustrato. 28. Relazioni tra il clima dell 'intero bacino del fiume Piave ed il regime del corso medio-inferiore. 29. Il Montelli (clima e acque). 30. Clima del medio e alto Adige. 31. Elementi meteoroclimatici della Boemia e Moravia.

[2] See more detailed discussions in the REVIEW, 1918, November, pp. 537–538, December, p. 599; 1919, January, p. 52, February, p. 130, March, p. 192

King, Louis V[essot].
Preliminary report on researches on sound measurement with reference to the testing of fog-signal machinery. Ottawa. 1918. cover-title, 8 p. 23½ cm. At head of title: Dominion of Canada. The honorary advisory council for scientific and industrial research. Bulletin no. 2.

Kuenen, J[ohannes] P[etrus] & Clark, A[rthur] L.
Critical point, critical phenomena and a few condensation-constants of air. Leiden. [1917] 2 tables. 2 charts. 24½ cm. (Communications from the Physical laboratory of the University of Leiden, No. 150, p. 53–65.) (Translated from: Verslagen van de Gewone vergadering der wissen natuurkundige afdelling der Kon. Akad. van wetenschappen te Amsterdam, 24 Februari 1917, Deel 25, p. 1087–1096.)

McBeth, I. G. & Allison, J. R.
Recent investigations in orchard heating. illus. charts. 34½ cm. (Excerpted from the California citrograph, Los Angeles, Cal. vol. 4, no. 3. Jan., 1919. p. 51, 65 & 67.)

Mysore. Meteorological department.
Mysore meteorological memoirs. No. 3. Hourly values of the weather elements obtained with the self-recording instruments at the Bangalore observatory, 1907. Bangalore. 1918. 3 p.l., 102 p. incl. tables. 31½ cm.

Nantun. Chen-shan meteorological observatory.
Annual [report] 1917. Nantun. 1918. illus. plates (incl. ports.) charts. plan. tables (part. fold.) 29 cm. Various pagings. In Chinese and English.

Rio de Janeiro. Observatorio nacional.
Annuario para o anno de 1919. Anno 35. Rio de Janeiro. 1918. vii, 502 p. fold. chart. tables. 18½ cm. At head of title: Ministerio da agricultura, industria e commercio. [Meteorological observations, p. 319–413.]

Sandström, J[ohan] W[ilhelm].
Om bearbetning av vindobservationer enligt Lamberts formel. Stockholm. 1919. cover-title, 9 p. 6 charts. 23 cm. At head of title: Meddelanden från K. Vetenskapsakademiens Nobelinstitut. Band 5. No. 24.

Schott, Gerhard.
Ozeanographie und Klimatologie des Persischen Golfes und des Golfes von Oman. Berlin. 1918. 46 p. charts (part. fold.) tables. 27 cm. At head of title: Kaiserliche Marine. Deutsche Seewarte. (Beilage zu den "Annalen der Hydrographie und maritimen Meteorologie" 1918.)

South Africa. Department of agriculture.
Report with appendices for the year ended 31st March, 1918. Cape Town. 1918. 2 p.l., 170 p. tables. 33 cm. [Weather conditions, p. 165–168.]

Spain. Observatorio central meteorológico.
Anuario 3. Madrid [1918] iv, 310 [3] p. fold. map. charts. tables. 31½ cm. At head of title: Dirección general del Instituto geográfico y estadístico. [Climatological observations, 1917. Upper air observations, 1915–1916.]

Sweden. Meteorologisk Centralanstalt.
Bihang I till Meteorologiska iakttagelser i Sverige. Band 57. 1915. Askdagarnes frekvens i Sverige 1730–1915 av H. E. Hamberg. Appendice I aux Observations météorologiques suédoises. Vol. 57. 1915. Frequénce des jours d'orage en Suède 1730–1915, par H. E. Hamberg. Stockholm. Uppsala. 1917. 3 p.l., 174 p. 10 fold. charts. tables. 31 cm.
Bihang 2 till Meteorologiska iaktallagelser i Sverige. Band 57. 1915. Pilotballongobservationer i Abisko 1913-1915. Appendice 2 aux Observations météorologiques suédoises. Vol. 57. 1915. Lancers de ballons-pilotes à Abisko en 1913–1915. Stockholm. Uppsala. 1917. p.l., 59 p. tables. 31 cm. Bihang 2A. Pilotballongobservationer i Abisko, 1913, av A. Funke . . . Bihang 2B. Pilotballongobservationer i Abisko, 1914 och 1915, av Ragnar Carlstedt. . . .
Meteorologiska iakttagelser i Sverige. Band 57–58. 1915–1916. Observations météorologiques suédoises. Vol. 57–58. 1915–1916. Stockholm [Uppsala. 1917–1918.] 2v. tables. 31 cm.

Taylor instrument companies.
Tycos tables; general data concerning and for use with temperature indicating, recording, and controlling instruments; hydrometers and meteorological instruments. . . . Rochester, N. Y. [c1918] 175 p. illus. (incl. blueprints.) tables. 16 cm.

Varney, Burton M.
Thirty-year synopsis. Meteorological observations made at Berkeley from July 1, 1887, to June 30, 1917. Berkeley. 1919. cover-title. charts. tables. 27½ cm. At head of title: University of California publications in geography, Vol. 2, No. 1, pp. 1–18.

Wallén, Axel.
Första skandinaviska geofysikermötet i Göteborg den 28–31 augusti 1918. Stockholm. 1918. 23½ cm. (Ur Ymer, tidskrift utgiven av Svenska sällskapet för antropologi och geografi, Årg. 1918, H. 3, p. [278]–294.)
Nederbörd, afrinning och afdunstning i Lagans vattenområde. [Stockholm. 1918]. cover-title, 35 p. charts. 7 tables. 20½ cm. At head of title: Från Hydrografiska byrån. (Särtryck ur Teknisk tidskrift, Väg-och vattenbyggnadskonst, 1918, Häfte 11.)
Om afdunstningsbestämningar. Stockholm. 1918. cover-title, 18 p. 3 tables. 21½ cm. At head of title: Från Hydrografiska byrån. (Särtryck ur Teknisk tidskrift, Veckoupplagan 1918, Häft. 44.)

Weber, Sophus.
Investigation relating to the vapour pressure of ice. Leiden. [1917] illus. charts. tables. 24½ cm. (Communications from the Physical laboratory of the University of Leiden, No. 150, p. 1–52.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Aeronautics. London. v. 16. March 20, 1919.
Vickers, Ltd. The weather as affecting airship traffic. p. 306.
Astrophysical journal. Chicago. v. 49. March, 1919.
Luckiesh, M. Aerial photometry. p. 108–130.
Geographical journal, London. v. 53. April, 1919.
The climate of Constantinople. p. 282–283. [Abstr. from Petermanns Mitteilungen.]
Franklin institute. Journal. Philadelphia. v. 187. March, 1919.
Luckiesh, M. The visibility of airplanes. p. 289–312.
Royal society. Proceedings. London. v. 95. No. A 668. 1919.
Hercus, E. O., & Laby, T. H. The thermal conductivity of air. p. 190–210.
Chree, C[harles]. Electric potential and atmospheric opacity at Kew observatory. p. 210–234.
Science. New York. v. 49. March 28, 1919.
Dabney, T. G. Curious differentiation in frost effects. p. 310–311. [Localization of frost attributed to quality of soil.] p. 310–311.
Scientific American supplement. New York. v. 87. 1919.
Ritter, Wm. E., & McEwen, F. Ocean temperatures and seasonal weather in southern California. p. 224. (Apr. 5.) [Repr. from Mo. Wea. Rev., Nov. 1918. p. 512.]
Winchell, A. N., & Miller, E. R. The dustfall of March, 1918. p. 234–235. (Apr. 12.) [Repr. from Amer. Journ. Sci., & Mo. Wea. Rev.]
Palmer, Andrew H. Water power in California. The factors on which it depends and the extent to which it might be utilized. p. 260–261:271. (Apr. 26.) [Repr. Journal of Geography.]
Symons meteorological magazine. London. v. 54. March, 1919.
Capt. Melville Willis Campbell Hepworth, C. B., R. D., R. N. R. Cheltenham, 27th April, 1849—Ealing, 25th February, 1919. p. 13–14. [Obituary.]
Martin-Smith, A. S. The care of the barograph. p. 14–15.
Tycos-Rochester. Rochester. v. 9. April, 1919.
The barometer—the key to weather mystery. p. 16–17; 19. [Repr. Canadian Optometrist & Optician.]
Académie des sciences. Comptes rendus. Paris. Tome 168. 1919.
Dunoyer, L., & Reboul, G. Sur la prévision des variations barométriques: vents d'appel pour les dépressions. p. 457–459. (3 mars.)

Académie des sciences. Comptes rendus. Paris. Tome 168. 1919—Con.

Guilbert, Gabriel. Sur les anomalies de la station météorologique de Skudesness (Norvège.) p. 460–461. (3 mars.) [Direction and force of wind at Skudenes, Norway, indicate presence of barometric depression far to the west of the British Isles, before its presence is revealed by observations at British stations.]

Levine, Joseph. Périodicité des vagues atmosphériques. p. 566–567. (17 mars.) [Author finds a 96-year period in the annual barometric minima for Paris.]

Hubert, Henri. Sur la prévision des grains orageux en Afrique occidentale. p. 567–570. (17 mars.)

Trillat, A., & Fouassier. Sur un appareil destiné à l'étude de la formation et la persistance des brouillards. p. 570–572. (17 mars.) [Studies on the different fog-forming properties of different kinds of condensation nuclei in the atmosphere.]

Dechevrens, Marc. La variation diurne du courant électrique vertical de la terre à l'air (observations faites à Jersey). p. 572–575. (17 mars.)

Hildebrandsson, H[ugo] H[ildebrand]. Réflexions préliminaires sur les mouvements généraux de l'atmosphère. p. 593–598. (24 mars.)

Reboul, G., & Dunoyer, L. Sur les actions mutuelles des basses pressions et des hautes pressions. p. 621–623. (24 mars.)

Baldit, Albert. Sur les orages de froid et leurs trajectoires. p. 623–625. (24 Mars.)

Correspondant. Paris. 91 annee. 10 avril 1919.

Guilbert, Gabriel. La météorologie d'après-guerre. p. 156–161.

France. Service météorologique aux armées. Bulletin. 1918.

Brazier, Goutereaux W. Le nuage, auxiliaire de l'aviateur. p. 5–21. (Jan.) [A study of clouds in reference to their strategic value in military aviation.]

[Grignoux.] Étude sur les variations du vent. p. 23–43. (Jan.)

[Grandpierre.] Méthode de prévision barométrique d'après le mémoire de M. Francesco Vercelli. p. 47–58. (Jan.)

Dunoyer. La méthode du Capitaine Dunoyer pour la détermination du vent balistique. p. 59–60. (Jan.)

Les progrès accomplis depuis la guerre dans l'utilisation des renseignments météorologiques par l'artillerie. p. 60–64. (Jan.)

Renseignments sur le service météorologique dans l'armée allemande, d'après des traductions de documents allemands. p. 65–74. (Jan.)

L'avertissement des grains. p. 1–12. (10 oct.) [Describes squall-warning service of French army during the war.]

Note pour le bi-enregistreur pour ballon-sonde. p. 13–21. (10 oct.)

Société Languedocienne de géographie. Bulletin. Montpellier. Tome 41. 1918.

Moye, M[arcel]. La scintillation des étoiles et la prévision du temps. p. 37–39.

Moye, M[arcel]. Les tremblements de terre dans le midi de la France et la Catalogne. p. 40–43.

Raymond, G. La pluie et les orages en relation avec la rotation du soleil en Provence. p. 44–47.

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 44. Jahrgang. 1916.

Köppen, W[ladimir]. Die Dreizehnteilige Skala der Windstärken. p. 57–63. (H. 2.)

Schmidt, Wilhelm. Zur Frage der Verdunstung. p. 136–145. (H. 3.)

Eckardt, W[ilhelm] R[ichard]. Über die Ursachen der jahreszeitlichen Regenfälle in den westlichen Mittelmeerländern. p.193–205. (H. 4.)

Van der Wyk, P. H. Nebelsignale. (Verbessertes System.) p. 208–212. (H. 4.)

Köppen, W[ladimir]. Landnebel und Seenebel. p. 233–257. (H. 5.) [Concluded 1917 (H. 10) p. 401–408. Includes extensive statistics of fog for various parts of the world.]

Eckardt, W[ilhelm R[ichard]. Über die Ursachen der jahreszeitlichen Regenfälle in den westlichen Mittelmeerländern. p. 257–269. (Conclusion.) (H. 5.)

Barkow, E[rich]. Über die Meteorologie des südlichen Rossmeeres und die Meereshöhe des Südpolarplateaus. p. 316–327. (H. 6.)

Meinardus, W[ilhelm]. Über die meteorologischen Arbeiten der deutschen Südpolar-Expedition 1901 bis 1903. p. 327–329. (H. 6.)

Reinicke, G. Beobachtungen über die Sichtigkeit der Luft. p. 329–333. (H. 6.)

Grossmann, [Louis Adolf]. Die Sturmfluten an der deutschen Nordseeküste am 13. Januar und 16/17. Februar 1916. p. 361–380. (H. 7.)

Ludewig, P[aul]. Neue Beobachtungen über die Ausbreitung starker Schallwellen in der Atmosphäre. p. 381–388. (H. 7.)

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 44. Jahrgang. 1916—Continued.

Sverdrup, H. U. Druckgradient, Wind und Reibung an der Erdoberfläche. p. 413–427. (H. 8.)

Hackenbroisch, Anton. Die unperiodischen Schwankungen des Luftdrucks und Regens im Tropengebiet des Atlantischen Ozeans. p. 427–441, 477–487, 505–519. (H. 8, 9, and 10.)

Schuster, P. Die Verschiebung des synodischen Luftdrucksystems unter dem Einfluss der 18.6-jährigen Mondperiode. p. 442–444. (H. 8.)

Grossmann, [Louis Adolf]. Professor Dr. Wladimir Köppen zu seinem 70. Geburtstag. p. 457–461. (H. 9.) [With list of Köppen's meteorological writings, p. 459–461.]

Meissner, Otto. Über der örtlichen Einfluss von Luftdruck und Wind auf den Wasserstand der Ostsee. p. 473–477. (H. 9.) [Continued 1917, p. 227–232. (H. 6.)].

Hackenbroisch, Anton. Die unperiodischen Schwankungen des Luftdrucks und Regens im Tropengebiet des Atlantischen Ozeans. p. 477–487. (Continuation.) (H. 9.)

Immler, W. Die Bestimmung von Windrichtung und -stärke im fahrenden Flugzeug. p. 497–504. (H. 10.)

Hackenbroisch, Anton. Die unperiodischen Schwankungen des Luftdrucks und Regens im Tropengebiet des Atlantischen Ozeans. p. 505–519. (Conclusion.) (H. 10.)

Brennecke, Wilhelm. Henrik Mohn. p. 526–527. (H. 10.) [Obituary.]

Gallé, P. H., & Schott, G[erhard]. Zur Frage der Lufttemperatur an der Meeresoberfläche. p. 527–530. (H. 10.)

Köppen, W[ladimir]. Die vertikale Gliederung der täglichen Windperiode in Cyklonen und Anticyklonen. (Erste Ergebnisse der Windmessstelle Eilvese.) p. 537–542. (H. 11.) [Results of observations on radio towers at Eilvese, Germany.]

Eckardt, Wilhelm R[ichard]. Über Luftdruckverteilung und Regenfall in Asien mit besonderer Berücksichtigung der Randgebiete. p. 542–554. (H. 11.)

Brennecke, W[ilhelm]. Beziehungen zwischen der Stärke des Nordost-Passats im Sommer und der Wintertemperatur von Europa. p. 565–567. (H. 11.)

Grossmann, [Louis Adolf]. Die Psychrometerformel. p. 577–599. (H. 12.)

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 45. Jahrgang. 1917.

Barkow, E[rich]. Windänderung mit der Höhe und Turbulenz. p. 1–6. (H. 1.)

Eckardt, W[ilhelm] R[ichard]. Über die Ursachen der jahreszeitlichen Regenfälle in Afrika mit besonderer Berücksichtigung der Küstengebiete. p. 7–19. (H. 1.)

Schuster, F. Vom Einfluss des tropischen Monate auf den Luftdruck, die Windbewegung, die Temperatur und die wässerigen Niederschläge. p. 41–49. (H. 2.)

Defant, A[lbert]. Die Verteilung des Luftdrucks über dem nordatlantischen Ozean und den angrenzenden Teilen der Kontinente auf Grund der Beobachtungsergebnisse der 25-jährigen Periode 1881 bis 1905. p. 49–65. (H. 2.)

Drewes, F. Einige Beziehungen zwischen der Luftdruckverteilung bei Island und dem Wetter an der deutschen Küste. p. 65–72. (H. 2.)

Deutsche Seewarte. Professor Dr. L. Grossmann. p. 85–87. (H. 3.) [Obituary and list of publications.]

Eckardt, W[ilhelm] R[ichard]. Luftdruckverteilung, Winde und Regenfall in Australien. p. 106–110. (H. 3.)

Wenger, R[obert]. Die Steigegeschwindigkeit der Gummiballone und die Turbulenz in der Atmosphäre. p. 121–137. (H. 4.)

Barkow, E[rich]. W. Blair. Das planetare Windsystem. p. 146–152. (H. 4.)

Barkow, E[rich]. Der tägliche Gang der Lufttemperatur in sehr hohen Luftschichten. p. 157–158. (H. 4.)

Schneider, J. Die Wiederkehr der jährlichen und monatlichen Änderungen des Luftdrucks über Mitteleuropa. p. 162–185, 201–216. (H. 5 and 6.)

Meissner, Otto. Über die Beziehung der Temperatur zur Sonnenfleckenperiode. p. 186–191. (H. 5.)

Schneider, J. Die Wiederkehr der jährlichen und monatlichen Änderungen des Luftdrucks über Mitteleuropa. p. 201–216. (Conclusion.) (H. 6.)

Schuster, F. Die Interferenz von tropischen mit dem drakonitischen Luftdrucksystem, direkt im Gang des Luftdruckes nachgewiesen. p. 224–227. (H. 6.)

Meissner, Otto. Über den örtlichen Einfluss von Luftdruck und Wind auf den Wasserstand der Ostsee. p. 227–232. [Continuation.] (H. 6.)

Schulz, Bruno. Die jährliche und halbjährliche Periode im Wasserstande der Nord- und Ostsee. p. 252–258. (H. 7.) [Discusses meteorological factors.]

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 45. Jahrgang. 1917—Continued.

Hoecken, K. Graphische Darstellung des Verlaufs der bürgerlichen und astronomischen Dämmerung. p. 258–259. (H. 7.)

Hesselberg, Th., & Birkeland, D. J. Über die Steigegeschwindigkeit der Pilotballone. p. 313–324. (H. 9.)

Sverdrup, H. U. Zur Bedeutung der Isallobarenkarten. p. 325–329. (H. 9.)

Köppen, W[ladimir]. Landnebel und Seenebel. p. 401–408. [Conclusion.] (H. 10.)

Reinicke, G. Beobachtungen über Sichtigkeit der Luft. p. 416–418. (H. 10.)

Köppen, W[ladimir]. Anzeichen für eine 89-jährige Periode der kalten Winter in Europa. p. 445–452. (H. 11.)

Thraen, August. 40 Jahre monatlicher Termin- und Extrem-Mittelwerte der Temperatur in Hamburg. p. 519–524. (H. 12.)

Brennecke, W[ilhelm]. Die mittlere Lage des Eises in den nordpolaren Meeren. p. 524–527. (H. 12.)

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 46. Jahrgang. 1918.

Mecking, Ludwig. Nordamerika, Nordeuropa und der Golfstrom in der elfjährigen Klimaperiode. p. 1–17. (H. 1.)

Schneider, J. Die Meyer-Seemannsche Luftdruckschwankung im Lichte einer sechsjährigen Mondperiode. p. 20–30. (H. 1.)

Köppen, W[ladimir]. Der nordatlantischen Passat. p. 31–36. (H. 1.) [Review of work by Sverdrup.]

Bucking, [Hugo]. Die Hörbarkeit des Kanonendonners insbesondere die Fälle mit grosser Reichweite. p. 36–43. (H. 1.)

Köppen, W[ladimir]. Die jährliche und räumliche Verteilung der Gewitter und Böen auf dem nordatlantischen Ozean und dessen Küsten. p. 64–78. (H. 2.)

Defant, A[lbert]. Neue Methode zur Ermittlung der Eigenschwingungen (Seiches) von abgeschlossenen Wassermassen (Seen, Buchten, usw.). p. 78–85. (H. 2.)

Meissner, Otto. Seegang in Norwegen und mikroseismische Bewegung. p. 85–92, 183–190. (H. 2, 5/6.)

Hesselberg, Th. Über die Stabilitätsverhältnisse bei vertikalen Verschiebungen in der Atmosphäre und im Meer. p. 118–129. (H. 3/4.)

Schmidt, Wilhelm. Ausfüllende, im Sinne des Druckgefälles verlaufende Luftströmungen unter verschiedenen Breiten. p. 130–132. (H. 3/4.)

Meissner, Otto. Seegang in Norwegen und mikroseismische Bewegung. p. 183–190. [Conclusion.] (H. 5/6.)

Sverdrup, H. U. Die Beziehung der elfjährigen Klimaschwankungen zur Sonnentätigkeit. p. 191–193. (H. 5/6.)

Schuster, F. Über die Beziehungen zwischen dem Luftdruck und den nassen Niederschlägen im synodischen Monat. p. 193–194. (H. 5/6.)

Thorade, H[ermann]. Die Sturmflut vom 15. und 16. Januar 1916 in den dänischen Gewässern. p. 234–238. (H. 7/8.)

Ryd, V. H. Die Reibung in der Atmosphäre. p. 242–246. (H. 7/8.)

Horn, A. v. Die Sturmfluten längs den Nordsee- und den Zuiderzee-Küsten in Verbindung mit der Abschliessung der Zuiderzee. p. 318–324. (H. 11/12.)

Schmidt, Wilhelm. Über Arbeitsleistung und Arbeitsverbrauch in der freien Luft. p. 324–332. (H. 11/12.)

Immler, W. Ein Universaldiagramm zur Lösung des Winddreiecks. p. 370–377. (H. 11/12.)

Wegemann, [Georg]. Auchters "Selbstschreiber" für lange Dauer. p. 380–385. (H. 11/12.) [Describes registering apparatus for meterorological instruments capable of running a year or more without attention.]

Reinecke, G. Beobachtungen über Sichtigkeit der Luft. p. 386–387. (H. 11/12.)

Beiträge zur Physik der freien Atmosphäre. Leipzig. 7. Band. Heft 3. 1916.

Schmidt, Wilhelm. Schrumpfen und Strecken in der freien Atmosphäre. p. 103–149.

Tetens, Otto. Eine neue Form von Instrumenten zur Verfolgung von Pilotballonen. p. 150–155.

Hesselberg, Th., & Sverdrup, H. U. Die Windänderung mit der Höhe vom Erdboden bis etwa 3000 m. Höhe. p. 156–166.

Dietzius, R[obert]. Schwingungen des Freiballons. p. 167–173.

Dietzius, Robert. Die Geschwindigkeit des Windes in grossen Höhen über Wien. p. 174–184.

Beiträge zur Physik der freien Atmosphäre. Leipzig. 8. Band. Heft 1. 1918.

Gruner, P[aul]. Die Dämmerungserscheinungen nach bisherigen und neueren Beobachtungen in der Schweiz. p. 1–28.

Dietzius, Robert. Die Gestalt der Stromlinien in der Nahe der singulären Punkte. p. 29–52.

Die Naturwissenschaften. Berlin. 6. Jahrgang. 27. Dezember, 1918.

Prey, Adalbert. Der skandinavische Geophysikerkongress in Göteborg. (28.–31. August, 1918.) p. 765–768.

Petermann's Mitteilungen. Gotha. 64. Jahrgang. November-Dezember, 1918.

Köppen, Wladimir. Klassifikation der Klimate nach Temperatur, Niederschlag und Jahreslauf. p. 243–248. [Conclusion.]

Wetter. Berlin. 34. Jahrgang. 1917.

Thraen, August. Das Klima Westrusslands. p. 1–5. (Jan.)

Göschl, Franz. Eine 3.2 monatliche Schwankung der meteorologischen Elemente. p. 5–6. (Jan.)

Thraen, August. Das Klima von Rumänien. p. 11–12. (Jan.)

Fischer, Rudolf. Einfluss des Hoch- und Tiefstandes des Mondes auf Erwärmung und Abkühlung in der wärmeren Jahreszeit. p. 12–16. (Jan.)

Wegner, Rudolf. Mittlerer täglicher Gang des Sonnenscheins in Minuten für Berlin. p. 18–19. (Jan.)

Boll, K. Der Kälteeinbruch im September. 11.–26 September, 1916. p. 19–23. (Jan.)

Eckardt, W[ilhelm] R[ichard]. Luftdruckverteilung und Regenfall auf der Balkanhalbinsel, besonders in deren nordöstlichen Teile. p. 25–31. (Feb.)

Lindemann, [Carl]. Die mittlere Sonnenscheindauer in Charandt und Dresden, 1911–1915. p. 35–47. (Feb.)

Hofmann, A. Ein Vorschlag. p. 47–48. (Feb.) [Suggests use of cinematograph for showing pressure changes.]

Assmann, Richard. Nachruf für Professor Dr. Louis Grossmann. p. 49–50. (März /Apr.) [Obituary.]

Hornberger, [R]. Der tägliche Barometergang in Hann.-Münden. p. 50–66. (März/Apr.)

Richarz, [Franz]. Über die Farbe des Mondes, Farbenerscheinungen an Wasserfällen und an Wolken. p. 69–71. (März/Apr.)

Schmauss, [August]. Das Summen der Telegraphendrähte. p. 73–74. (März/April.)

Molly. Ein Modell einer Wasserhose im Schulhof. p. 76. (März/Apr.)

Hennig, Richard. Der strenge Winter 1917. p. 76–79. (März/Apr.)

Meissner, Otto. Bemerkenswerte Witterungsereignisse der letzten Jahre. (1908–1914.) p. 81–84. [Continuation.] (März/Apr.)

Gallenkamp, W. Versuch einer Bezifferung des Wetters. p. 85–91. (May.) [Describes a numerical method of recording the weather as a whole.]

Drewes, F. Die Kälteperiode im Januar und Februar 1917. p. 91–98. (May.)

Rudel, K[aspar]. Der Mond und das Wetter. p. 107–108. (May.)

Dietzius, Robert. Die Beziehung zwischen Windgeschwindigkeit und Luftdruckgefälle. p. 109–115. (Juni.)

Naegler, [Wilhelm]. Das Winterklima von Wilna mit besonderer Berücksichtigung des Kriegswinters 1915/16. p. 118–121. (Juni.)

Thraen, August. Das Klima von Serbien, Montenegro und Albanien. p. 121–123. (Juni.)

Eckardt, W[ilhelm] R[ichard]. Winterkälte und Sonnenfleckenmaximum. p. 125–126. (Juni.)

Meissner, Otto. Die Temperatur des ersten Dritteljahrs 1917. p. 126–127. (Juni.)

Veenems, C. Die Hörweite des Gewitterdonners. p. 127–130; 187–192, 258–262, [concluded, 56–68, Mar./Apr., 1918]. (Juni, Aug./Sept., Dec.).

Hofmann, Albert. Beiträge zur atmosphärischen Polarisation. 1. p. 133–138. (Juli.)

Meyer, G. Lassen sich Vermutungen über den Verlauf des diesjährigen Sommerwetters und des Ausfall der Ernte aufstellen? p. 138–140. (Juli.)

Meissner, Otto. Die Sonnenfleckenperiode im Klima von Berlin. p. 148–151. (Juli.)

Molly. Nachtrag zu der Schilderung des Modells der Wasserhose im Schulhofe. p. 154. (Juli.)

Schmidt, Felix. Niederschläge durch starke Rauchentwickelung. 155–156. (Juli.) [Rain and thunderstorms caused by smoke from forest fires in U. S.]

Eckardt, W[ilhelm] R[ichard]. Über Zyklonenzug und Regenfall in Vorderasien. p. 157–168. (Aug.)

Hoffmann, Albert. Beiträge zur atmosphärischen Polarisation. p. 168–174. (Aug./Sept.)

Hergesell, H[ugo]. Waldbrand und Wolkenbildung. p. 178–179. (Aug./Sept.) [With photograph of cloud formed over a burning wood.]

Klengel, F[riedrich]. Die Wetterwarte zu Plauen in i. V. p. 179–182. (Aug./Sept.)

Sassenfeld, Max. Erdbodentemperatur in Württemberg. p. 182–184. (Aug./Sept.)

Wetter, Berlin. 34. Jahrgang. 1917——Continued.

Veenema, C. Die Hörweite des Gewitterdonners. p. 187–192. [Continuation.] (Aug./Sept.)

Göschl, Franz. Wettertabellen für die drei Sommermonate Juni-August 1917. p. 193–197. (Okt.)

Hofmann, Albert. Beiträge zur atmosphärischen Polarisation. p. 197–204. [Continuation.] (Okt.)

Fischer, Rudolf. Der Altweibersommer vom 16. September bis 3. Oktober 1917 in Frankfurt a. Main. p. 212–214. (Okt.)

Meissner, Otto. Radiometerbeobachtungen. p. 217–222. [Continuation.] (Nov.)

Thraen August. Graphische Darstellung der Windhäufigkeit. p. 222–225. (Nov.)

Thraen, August. Graphische Darstellung der Windhäufigkeit. p. 241–246. [Conclusion.] (Dez.)

Veenema, C. Die Hörweite des Gewitterdonners. p. 258–262. [Continuation.] (Dez.)

Rudel, [Kaspar]. Irdische Kälte. p. 262–264. (Dez.)

Wetter. Berlin. 35. Jahrgang. 1918.

Assmann, Richard. Nachruf für Rudolf Fuess. p. 1–8. (Jan./Feb.) [Obituary.]

Hofman, Albert. Beiträge zur atmosphärische Polarisation. p. 8–17. [Continuation.] (Jan./Feb.)

Eckardt, W[ilhelm] R[ichard]. Über die Nothwendigkeit der Erweiterung des Wetterkartenbildes nach dem Kriege im Interesse der Zuverlässigkeit der Wettervorhersage. p. 37–45. (März/Apr.)

Lindemann, C[arl]. Die Erdboden-Temperatur in Dresden. N. 1908/13. p. 49–52. (März/Apr.)

Göschl, Franz. Wettertabelle für den Herbst 1917. p. 52–53. (Marz/Apr.)

Fischer, Rudolf. Kälte und Schnee im Dezember 1917. p. 53–55. (März/Apr.)

Veenema, C. Die Hörweite des Gewitterdonners. p. 56–68. [Conclusion.] (März/Apr.)

Salle, Otto. Richard Assmann. p. 69. (Mai/Juni.) [Obituary.]

Peppler, A[lbert]. Richard Assmann. p. 70–79. [Mai/Juni.) [Obituary.]

Thraen, August. Das Vorzeichen bei unperiodischen Abweichen in der Klimatologie. p. 80–87. (Mai/Juni.)

Sassenfeld, Max. Ergebnisse 50 jähriger Niederschlagsmessungen in Freudenstadt im Schwarzwald. p. 91–93. (Mai/Juni.)

Diesner, P. Über Wind und Wasserhosen. p. 93–96. (Mai/Juni.) [Records several cases of landspouts and waterspouts not given in Wegener's recent book on the subject.]

Eckardt, W[ilhelm] R[ichard]. Über die Ursache abnormer Beziehungen zwischen Barometerstand, Isobarenverlauf und Windrichtung. p. 96–97. (Mai/Juni.)

Fischer, Rudolf. Werden die Monate Mai in den Jahren 1918 bis 1922 in der Mehrzahl kühler? p. 97–98. (Mai/Juni.)

Baschin, Otto. Die Winterstrenge als klimatischer Faktor. p. 101–104. (Juli/Aug.)

Eckardt, W[ilhelm] R[ichard]. Luftdruck und Regenfall im Mittelmeergebiet. p. 109–115. (Juli/Aug.)

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Wetter. Berlin. 35. Jahrgang. 1918—Continued.

Köppen, W[ladimir]. Angenehme Temperaturen. p. 116–117. (Juli/Aug.)

Wiese, Bruno. Allgemeines über den Ablauf der Witterung auf der Balkanhalbinsel. p. 120–122. (Juli/Aug.)

Naegler, [Wilhelm]. Der strenge Winter 1916/17 in Kobylnik (Russland). p. 124–128. (Juli/Aug.)

Boll, K. Beobachtung von Kugel- und Perlschnurblitzen in Jambol (Bulgarien). p. 130. (Juli/Aug.)

Peppler, Albert. Kaltenbrunners statistiche Methode der Wettervoraussage. p. 133–136. (Sept./Okt.)

Schmidt, Wilhelm. Was lässt sich aus Regenfallstreifen herauslesen? p. 136–140. (Sept./Okt.)

Goerges, Hans. Der heisse Tag am 22. August 1918. p. 140–144. (Sept./Okt.)

Hofmann, Albert. Beiträge zur atmosphärischen Polarisation IV. p. 144–150. (Sept./Okt.)

Lindemann, C[arl]. Fünfzigjährige Monats- und Jahresmittel der Temperatur in Dresden, Leipzig, Bautzen, Pittau, Chemnitz, Freiberg, Elster und Reitzenhain, 1866–1915. p. 155–158. (Sept./Okt.)

Stöhr, [Anton]. Die ältesten Temperaturbeobachtungen in Böhmen. p. 159–160. (Sept./Okt.)

P[eppler], A[lbert]. Das Klima von Bosnien und Herzegovina. p. 160–162. (Sept./Okt.)

Dreis, Johannes. Über die Ursache strenger Winter. p. 162–164. (Sept./Okt.)

Peppler, Albert. Untersuchungen über die Geschwindigkeit und Böigkeit des Windes. p. 165–175. (Nov./Dez.)

Freybe, O[tto]. Über das Verhalten des Luftdruckes zu den Zeiten des Neu- und Vollmondes. p. 175–179. (Nov./Dez.)

Hofman, Albert. Beiträge zur atmosphärischen Polarisation. p. 179–183. [Conclusion.] (Nov./Dez.)

Meissner, Otto. Die Temperatur-und Bewölkungsverhältnisse in Potsdam (Telegraphenberg.) p. 187–195.. (Nov/Dez.)

Hemel en Dampkring. Den Haag. 16 Jaargang. Februari 1919.

Cannegieter, H. G. Wind, temperatur en vochtigheid in de hoogere luchtlagen boven Soesterberg. p. 145–149. [Continuation.]

Monné, A. J. Neerslag te Nijkerk (1889–1918.) p. 149–152.

Geografia. Novara. anno 6. Novembre-dicembre 1918.

Bustico, Guido. I terremoti dell'Ossola. p. 481–484.

Pontificia accademia romana dei Nuovi Lincei. Roma. Anno 70. 1917.

Galli, Ignazio. Di altri fulmini globulari negli anni 1915 e 1916. p. 81–92.

Galli, Ignazio. Azione patologica dei lampi sulle lesioni del corpo umano. p. 103–106.

Martinelli, G. Terremoto umbro-aretino, 26 aprile 1917 (Centri sismiche). p. 113–118.

Società sismologica italiana. Bollettino. v. 21. 1918.

Cavasino, Alfonso. Velocità di propagazione delle onde sismiche nel terremoto di Calitri (Avellino) del 7 giugno 1910. p. 117–217.

HALO PHENOMENA OBSERVED DURING MARCH, 1919.

By WILLIS RAY GREGG, METEOROLOGIST.

Station.	Altitude.	Latitude.	Longitude.	Date.	Form observed.	Time of—		Theodolite readings.					
						Beginning.	Ending.	Time.	Radius inside.	Radius outside.	Length of arc.	Distance from sun or moon.	Altitude of sun or moon.
	m.	° ′	° ′						°	°	°	°	°
Broken Arrow, Okla.*	233	36 02	95 49	1	Solar halo, 22°	9:00 a. m.	10:17 a. m.	9:00 a. m.	22	23	270		23.5
				2	Solar halo, 22°	12:00 m.	3:00 p. m.						
				3	Solar halo, 22°	1:45 p. m.	3:00 p. m.	1:55 p. m.	22	23	90		43
				6	Solar halo, 22°	7:00 a. m.	7:25 a. m.				Partial.		
				6	Parhelion, right, 22°	7:00 a. m.	7:25 a. m.						
				6	Parhelion, left, 22°	7:00 a. m.	7:25 a. m.						
				12	Solar halo, 22°	8:30 a. m.	12:40 p. m.				Partial.		
				28	Solar halo, 22°	11:50 a. m.	3:00 p. m.						
				29	Solar halo, 22°	8:00 a. m.	9:55 a. m.						
				29	Solar halo, 22°	11:45 a. m.	2:00 p. m.						
				30	Solar halo, 22°	3:00 p. m.	4:00 p. m.						
Canton, N. Y.	137	44 36	75 10	4	Solar halo, 22°	11:10 a. m.	11:25 a. m.						
				6	Solar halo, 22°	11:20 a. m.	1:30 p. m.						
				8	Solar halo, 22°	2:35 p. m.	2:45 p. m.						
				8	Lunar halo, 22°	7:15 p. m.	9:00 p. m.						
				13	Solar halo, 22°	1:00 p. m.							
				14	Solar halo, 22°	7:30 a. m.	8:35 a. m.						
Cincinnati, Ohio	191	39 06	84 30	3	Solar halo, 22°	2:15 p. m.	2:40 p. m.						
				10	Solar halo, 22°	12:45 p. m.	2:50 p. m.						
				12	Lunar halo, 22°	10:10 p. m.	10:20 p. m.						
Dayton, Ohio	274	39 46	84 10	2	Solar halo, 22°	3:50 p. m.	4:15 p. m.						
				4	Solar halo, 22°	8:55 a. m.	9:25 a. m.						
				10	Solar halo, 22°	1:20 p. m.	1:45 p. m.						
				12	Lunar halo, 22°	8:45 p. m.	9:10 p. m.						
Drexel, Nebr.*	396	41 20	96 16	3	Solar halo, 22°	9:23 a. m.	11:00 a. m.	9:37 a. m.	22	22.5	200		27
				6	Solar halo, 22°	11:15 a. m.	1:30 p. m.	12:30 p. m.	22	22.5	130		42
				8	Solar halo, 22°	9:00 a. m.	1:00 p. m.	10:09 a. m.	22	22.5	200		33
				8	Parhelion, right, 22°	9:00 a. m.	10:30 a. m.	10:09 a. m.			5	28	33
				8	Parhelion, left, 22°	9:00 a. m.	10:30 a. m.	10:09 a. m.			5	28	33
				16	Parhelion, right, 22°	7:00 a. m.	7:25 a. m.	7:16 a. m.				23	5
				16	Parhelion, left, 22°	7:00 a. m.	7:16 a. m.	7:16 a. m.				23	5
Ellendale, N. Dak.*	444	45 59	98 34	1	Solar halo, 22°	12:28 p. m.	3:30 p. m.	1:40 p. m.	23	23.5	360		36
				3	Parhelion, right, 22°	4:30 p. m.	5:35 p. m.	4:50 p. m.			4	22	16
				3	Parhelion, left, 22°	4:30 p. m.	5:35 p. m.	4:50 p. m.			4	22	16
				3	Light pillar	4:30 p. m.	5:35 p. m.	4:50 p. m.			3		
				18	Solar halo, 22°	8:45 a. m.	10:00 a. m.	9:10 a. m.	20.5	21.5	360		23
				18	Parhelion, right, 22°	7:40 a. m.	8:58 a. m.				3		
				18	Parhelion, left, 22°	7:40 a. m.	8:58 a. m.				3		
				18	Lunar halo, 22°			2:30 a. m.					
				19	Solar halo, 22°	12:05 p. m.	1:00 p. m.	12:10 p. m.	21	22	360		
				30	Solar halo, 22°	8:45 a. m.	9:17 a. m.	8:50 a. m.	21	22	160		26
				30	Parhelion, right, 22°	8:52 a. m.	9:20 a. m.	8:55 a. m.			5	22	26
Groesbeck, Tex.*	141	31 30	96 28		None								
Leesburg, Ga.*	85	31 47	84 14	1	Solar halo, 22°	11:40 a. m.	1:15 p. m.	11:45 a. m.	22		360		
				2	Solar halo, 22°	3:00 p. m.	3:08 p. m.	3:04 p. m.	22		140		
				5	Solar halo, 22°	12:40 p. m.	2:40 p. m.	1:15 p. m.	22		120		
				6	Lunar halo, 22°	6:40 p. m.	D. N. p. m.	7:25 p. m.	22		320		
				7	Solar halo, 22°	12:55 p. m.	5:20 p. m.	2:15 p. m.	22		360		
				7	Parhelion, left, 22°	4:09 p. m.	5:20 p. m.	4:18 p. m.				22	16
				7	Lunar halo, 22°	6:15 p. m.	D. N. p. m.	7:30 p. m.	22		360		
				9	Solar halo, 22°	11:10 a. m.	11:50 a. m.	11:15 a. m.	22		360		
				10	Solar halo, 22°	9:50 a. m.	10:02 a. m.	9:55 a. m.	22		35		
				10	Lunar halo, 22°	6:25 p. m.	D. N.	6:37 p. m.	22		200		
				12	Lunar halo, 22°	9:15 p. m.	D. N.	11:00 p. m.	22		360		
				13	Lunar halo, 22°	7:27 p. m.	D. N.	8:40 p. m.	22		360		
				14	Lunar halo, 22°	6:55 p. m.	D. N.	9:05 p. m.	22		360		
				16	Lunar halo, 22°	8:40 p. m.	D. N.	9:30 p. m.	22		360		
				17	Solar halo, 22°	8:06 a. m.	9:10 a. m.	8:07 a. m.	22		180		
				24	Solar halo, 22°	4:30 p. m.	4:35 p. m.	4:30 p. m.	22		60		
				25	Solar halo, 22°	1:27 p. m.	3:00 p. m.	1:30 p. m.	22		120		
				25	Parhelion, right, 22°	4:20 p. m.	4:35 p. m.	4:30 p. m.				22	17
				26	Solar halo, 22°	9:45 a. m.	11:05 a. m.	9:45 a. m.	22	23	360		
				29	Solar halo, 22°	11:25 a. m.	11:45 a. m.	11:30 a. m.	22		75		
				30	Solar halo, 22°	3:25 p. m.	4:27 p. m.	3:52 p. m.	22		80		
Madison, Wis.	297	43 05	89 23	1	Solar halo, 22°	8:00 a. m.	3:00 p. m.						
				1	Parhelion, left, 22°	4:30 p. m.	5:00 p. m.						
				2	Solar halo, 22°	9:00 a. m.	12:30 p. m.						
				2	Parhelion, right, 22°	4:00 p. m.	Sunset.						
				2	Parhelion, left, 22°	4:30 p. m.	4:40 p. m.						
				2	Upper tangent arc	11:00 a. m.	12:30 p. m.						
				2	Lower tangent arc	11:00 a. m.	12:30 p. m.						
				2	Circumzenithal arc	4:00 p. m.	4:20 p. m.						
				3	Solar halo, 22°	7:48 a. m.	9:00 a. m.						
				6	Solar halo, 22°	7:43 a. m.	5:30 p. m.						
				7	Solar halo, 22°	Sunrise.							
				7	Parhelion, right, 22°	8:57 a. m.							
				7	Parhelion, left, 22°	8:47 a. m.							
				7	Upper tangent arc	7:43 a. m.	12:40 p. m.						
				7	Lower tangent arc	8:00 a. m.	12:40 p. m.						
				7	Circumscribed halo	11:20 a. m.	12:40 p. m.						
				7	Solar halo, 46°	7:43 a. m.	12:00 p. m.						
				7	Circumzenithal arc	7:43 a. m.	9:00 a. m.						
				7	Parhelic circle	11:45 a. m.							
				7	Paranthelion, right, 120°	12:00 m.	1:00 p. m.						
				7	Paranthelion, left, 120°	12:00 m.	1:00 p. m.						
				8	Solar halo, 22°	7:40 a. m.	4:00 p. m.						
				8	Parhelion, right, 22°	7:48 a. m.	3:30 p. m.						
				8	Parhelion, left, 22°	7:48 a. m.							
				8	Upper tangent arc	8:15 a. m.							
				8	Solar halo, 46°	7:48 a. m.	3:30 p. m.						
				8	Circumzenithal arc	7:54 a. m.	8:40 a. m.						
				8	Parhelic circle	11:00 a. m.							
				8	Paranthelion, right, 120°	11:12 a. m.							
				8	Paranthelion, left, 120°	11:12 a. m.							

* Aerological station.

Halo phenomena observed during March, 1919—Continued.

Station.	Altitude.	Latitude.	Longitude.	Date.	Form observed.	Time of—		Theodolite readings.					
						Beginning.	Ending.	Time.	Radius inside.	Radius outside.	Length of arc.	Distance from sun or moon.	Altitude of sun or moon.
	m.	° ′	° ′						°	°	°	°	°
Madison, Wis. (continued)				9	Parhelion, right, 22°...	7:15 a. m.	7:25 a. m.						
				12	Solar halo, 22°.....	2:42 p. m.	4:20 p. m.						
				12	Lunar halo, 22°.....	6:40 p. m.	D. N. P.						
				16	Solar halo, 22°.....	1:00 p. m.	Sunset						
				16	Lunar halo, 22°.....	Sunset	9:30 p. m.						
				16	Parhelion, right, 22°...	4:00 p. m.	Sunset						
				16	Parhelion, left, 22°....	4:00 p. m.	Sunset						
				16	Paraselene, right, 22°..	Sunset	9:30 p. m.						
				16	Paraselene, left, 22°...	Sunset	9:30 p. m.						
				16	Lunar halo, 46°.....	8:30 p. m.	9:30 p. m.						
				21	Parhelion, right, 22°...	7:00 a. m.	7:10 a. m.						
				22	Solar halo, 22°.....	2:45 p. m.	3:00 p. m.						
				22	Parhelion, right, 22°...	5:00 p. m.	Sunset						
				22	Parhelion, left, 22°....	5:00 p. m.	5:10 p. m.						
				23	Solar halo, 22°.....	4:07 p. m.	4:30 p. m.						
				23	Upper tangent arc....	4:12 p. m.	4:25 p. m.						
				24	Solar halo, 22°.....	10:45 a. m.	3:00 p. m.						
				24	Upper tangent arc....	10:45 a. m.	11:30 a. m.						
				25	Solar halo, 22°.....	12:15 p. m.	1:00 p. m.						
Nashville, Tenn	166	36 10	86 47	10	Solar halo, 22°.....	9:30 a. m.	1:00 p. m.	11:55 a. m.					
				12	Solar halo, 22°.....	6:30 p. m.	8:25 p. m.	7:00 p. m.					
				25	Solar halo, 22°.....	4:30 p. m.	5:30 p. m.	4:40 p. m.					
Rochester, N. Y	159	43 8	77 42	8	Solar halo, 22°.....	3:55 p. m.	4:30 p. m.	4:05 p. m.	21.7	22.7	300		17
				8	Upper tangent arc....	3:55 p. m.	4:30 p. m.				30	23	
				8	Solar halo, 46°.....	3:55 p. m.	4:03 p. m.				170		
				8	Circumzenithal arc....	3:55 p. m.	4:03 p. m.	3:55 p. m.			40	65	18.3
				13	Solar halo, 22°.....		5:50 p. m.	5:40 p. m.			75		1.5
				13	Lunar halo, 22°.....	6:40 p. m.	9:00 p. m.	7:45 p. m.			360		
Royal Center, Ind*	225	40 53	86 29	3	Solar halo, 22°.....	11:20 a. m.	1:30 p. m.	11:50 a. m.	21	23	360	22	42
				6	Solar halo, 22°.....	7:20 a. m.	1:30 p. m.	12:00 m.			180	22	
				7	Parhelion, right, 22°...	7:00 a. m.	7:40 a. m.	7:20 a. m.				22	
				7	Parhelion, left, 22°....	7:00 a. m.	7:40 a. m.	7:20 a. m.				22	
				12, 13	Lunar halo, 22°.....	7:50 p. m.	3:10 a. m.	0:00 p. m.			360	22	
				13	Solar halo, 22°.....	11:15 a. m.	12:30 p. m.	11:46 a. m.			180	22	
				24	Solar halo, 22°.....	11:30 a. m.	2:00 p. m.	1:00 p. m.			270	22	
				25	Solar halo, 22°.....	11:15 a. m.	12:15 p. m.	11:46 a. m.			360	22	
Tatoosh Island, Wash	26	48 23	124 44	4	Solar halo, 22°.....	11:26 a. m.	12:00 m.						
				4	Solar halo, 22°.....	2:26 p. m.	4:52 p. m.						
				4	Parhelion, right, 22°...	4:32 p. m.	4:33 p. m.						
				4	Parhelion, left, 22°....	4:45 p. m.	4:52 p. m.						
				5	Solar halo, 22°.....	8:55 a. m.	9:33 a. m.						
				5	Parhelion, right, 22°...	8:55 a. m.	9:33 a. m.						
				6	Solar halo, 22°.....	11:07 a. m.	11:55 a. m.						
				7	Solar halo, 22°.....	11:06 a. m.	11:23 a. m.						
				7	Parhelion, right, 46°...	11:12 a. m.	11:23 a. m.						
				7	Parhelic circle.....	11:12 a. m.	11:23 a. m.						
				8	Solar halo, 22°.....	11:50 a. m.							
				8	Parhelion, right, 22°...	11:50 a. m.	3:03 p. m.						
				8	Parhelion, left, 22°....	11:50 a. m.	3:03 p. m.						
				8	Light pillar.....	6:14 p. m.	6:33 p. m.						
				9	Solar halo, 22°.....	7:51 a. m.	8:17 a. m.						
				11	Lunar halo, 22°.....	7:28 p. m.	D. N. P.						
				12	Solar halo, 22°.....	11:54 a. m.	5:15 p. m.						
				12	Parhelion, left, 22°....	12:08 p. m.	12:15 p. m.						
				20	Solar halo, 22°.....	12:15 p. m.	4:12 p. m.						
				20	Parhelion, right, 22°...	2:35 p. m.	4:28 p. m.						
				20	Parhelion, left, 22°....	2:10 p. m.	4:28 p. m.						
				21	Solar halo, 22°.....	10:07 a. m.	6:17 p. m.						
				21	Parhelion, right, 22°...	9:50 a. m.	10:40 a. m.						
				21	Parhelion, left, 22°....	10:07 a. m.	10:40 a. m.						
				21	Light pillar.....	6:27 p. m.	6:44 p. m.						
				22	Lunar halo, 22°.....	4:25 a. m.	5:40 a. m.						
				22	Paraselene, right, 22°..	4:25 a. m.	5:06 a. m.						
				22	Upper tangent arc.....	4:38 a. m.	5:40 a. m.						
				22	Solar halo, 22°.....	7:17 a. m.	12:05 p. m.						
				22	Parhelion, right, 22°...	7:59 a. m.	9:30 a. m.						
				22	Lower tangent arc....	10:13 a. m.	10:25 a. m.						
				24	Lunar halo, 22°.....	4:30 a. m.	5:27 a. m.						
				24	Solar halo, 22°.....	3:15 p. m.	6:07 p. m.						
				24	Parhelion, right, 22°...	4:40 p. m.	5:00 p. m.						
				24	Parhelion, left, 22.....	4:40 p. m.	5:00 p. m.						
				24	Upper tangent arc.....	5:01 p. m.	5:34 p. m.						
				25	Solar halo, 22°.....	8:46 a. m.	10:10 a. m.						
				25	Parhelion, right, 22°...	7:45 a. m.	10:10 a. m.						
				25	Parhelion, left, 22°....	7:45 a. m.	10:15 a. m.						
				25	Parhelic circle.....	8:50 a. m.	8:53 a. m.						
				26	Solar halo, 22°.....	6:56 a. m.	8:25 a. m.						
				26	Solar halo, 22°.....	1:17 p. m.	6:10 p. m.						
				26	Parhelion, left, 22°....	5:35 p. m.	5:40 p. m.						
				29	Solar halo, 22°.....	2:25 p. m.	3:10 p. m.						
				29	Parhelion, right, 22°...	2:25 p. m.	2:40 p. m.						
				29	Parhelion, left, 22°....	2:25 p. m.	2:40 p. m.						
				29	Solar halo, 22°.....	5:00 p. m.	6:15 p. m.						
				31	Solar halo, 22°.....	9:49 a. m.	9:55 a. m.						
				31	Solar halo, 22°.....	3:58 p. m.	5:59 p. m.						
				31	Parhelion, right, 22°...	5:54 p. m.	5:59 p. m.						
				31	Parhelion, left, 22°....	5:54 p. m.	5:59 p. m.						
York, N. Y	232	42 52	77 53	4	Solar halo, 22°.....			8:30 a. m.			260		21.5
				9	Solar halo, 22°.....			4:00 p. m.			280		18
				10	Lunar halo, 22°.....			9:45 p. m.			360		
				11	Solar halo, 22°.....			8:30 a. m.			300		23

*Aerological station.

Halo phenomena observed during March, 1919—Continued.

Station.	Date.	Colors.†	Degree of brightness.	Clouds. Amount.	Kind.	Direction.	Station pressure.	Precipitation. Last previous ended.	First subsequent began.
Broken Arrow, Okla.*	1	Y	Bright	9	Ci. st.	wsw.	Stationary	9:40 a. m., 28th	9:50 a. m., 4th.
	2	Y	Faint	9	A. st.	w.	Stationary	9:40 a. m., 28th	9:50 a. m., 4th.
	3	Y	Faint	8	Ci. st.	wsw.	Falling	9:40 a. m., 28th	9:50 a. m., 4th.
	6	Y	Dim	8	A. st.	w.	Stationary	D. N., p., 4th	11:35 a. m., 6th.
	6								
	6								
	12	Y	Dim	10	Ci. st.	w.	Rising	4:40 p. m., 10th	3:05 p. m., 13th.
	28	R	Bright	6	Ci.	w.	Stationary	7:45 a. m., 26th	7:12 a. m., 2d.
	29	Y	Dim	10	A. st.	sw.	Stationary	7:45 a. m., 26th	7:12 a. m., 2d.
	29	Y	Dim	10	A. st.	sw.			
	30	Y	Dim	3	Ci. st.	w.	Stationary	7:45 a. m., 26th	7:12 a. m., 2d.
				5	St. cu.	ne.			
Canton, N. Y.	4	O	Dim	2	Ci. st.	w.	Falling	12:12 p. m., 1st	3:42 p. m., 4th.
	6	O	Dim	2	Ci. st.	w.	Rising	D. N., a., 5th	6:57 a. m., 7th.
	8		Dim	1	Ci. st.	w.	Falling	8:19 a. m., 7th	D. N., a., 9th.
	8		Dim	2	Ci. st.	w.	Falling		
	13		Dim	2	Ci.	w.	Rising	D. N., a., 13th	D. N., a., 16th.
	14		Dim	1	Ci. st.	w.	Stationary	D. N., a., 13th	D. N., a., 16th.
Cincinnati, Ohio	3	R, O	Dim	5	Ci. st.	nw.	Falling	5:15 p. m., 28th	1:00 a. m., 5th.
	10	R, O, Y, G, B	Brilliant	3	Ci. st.	w.	Falling	9:05 a. m., 9th	8:30 p. m., 10th.
				7	A. st.	w.			
	12		Bright	9	Ci. st.	nw.	Falling	D. N., p., 10th	4:10 a. m., 14th.
Dayton, Ohio	2		Dim	7	Ci. st.	sw.	Stationary	8:10 a. m., 1st	D. N., a., 5th.
	4		Dim	8	Ci. st.	w.	Falling	8:10 a. m., 1st	D. N., a., 5th.
	10		Dim	7	Ci. st.	w.	Falling	8:50 a. m., 9th	7:40 p. m., 10th.
	12		Dim	7	Ci. st.	w.	Stationary	8:55 p. m., 10th	8:05 p. m., 13th.
Drexel, Nebr.*	3	O, Y, G, B	Dim	6	Ci. st.	wsw.	Falling	7:00 a. m., 28th	5:45 p. m., 3d.
				3	A. st.	wsw.			
	6	O, Y, G, B	Dim	3	Ci. st.	sw.	Falling	10:22 a. m., 6th	4:50 p. m., 6th.
				4	A. st.	sw.			
	8	O, Y, G	Dim	6	Ci. st.	sw.	Falling	7:15 a. m., 7th	10:45 a. m., 9th.
	8	O, W	Dim						
	8	O, W	Dim						
	16	W	Dim	4	Ci. st.	sw.	Rising	1:05 p. m., 15th	8:35 p. m., 24th.
				3	St. cu.	wsw.			
	16	W	Dim	4	Ci. st.	sw.			
				3	St. cu.	wsw.			
Ellendale, N. Dak.*	1	R	Bright	6	St. cu.	nw.	Rising	9:55 a. m., 1st	10:45 a. m., 2d.
	3		Bright	1	A. st.	w.	Falling	1:30 p. m., 3d	D. N., a., 6th.
	3		Bright	2	A. cu.	w.			
	3		Bright	1	A. st.	w.			
				2	A. cu.	w.			
	18		Dim	3	Ci. st.	wnw.	Falling	8:45 p. m., 14th	10:00 a. m., 22d.
	18		Dim						
	18		Dim						
	18		Dim	4	Ci. St.	w.			
	19		Dim	7	Ci. St.	w.	Rising	8:45 p. m., 14th	10:00 a. m., 27th.
	30		Dim	3	Ci. St.	w.	Rising	8:25 a. m., 25th	2:00 p. m., 1st.
				2	Cu	ne.			
	30	R	Dim	3	Ci. St.	w.			
				2	Cu	ne.			
Groesbeck, Tex.*									
Leesburg, Ga.*	1	R, O, Y, G	Bright	6	Ci. St.	w.	Falling	11:40 a. m., 1st	D. N. a., 2d.
				4	A. Cu.	w.			
	2	R, O, Y, G	Dim	4	Ci. St.	w.	Stationary	11:28 a. m., 2d	2:58 p. m., 5th.
				6	A. St.	w.			
	5	R, O, Y, G	Bright	4	Ci. St.	sw.	Falling	11:28 a. m., 2d	2:58 p. m., 5th.
				5	St. cu.	sw.			
	6			9	Ci. St.	w.	Stationary	9:45 a. m., 6th	6:50 a. m., 8th.
	7	R, Y, G	Dim	9	Ci. St.	w.	Stationary	9:45 a. m., 6th	6:50 a. m., 8th.
	7	R, Y, G	Bright	1	Ci. cu.	w.	Stationary		
				6	Ci. St.	w.			
	7			10	Ci. St.		Rising		
	9	R, O, Y	Bright	2	Ci.	w.	Stationary	D. N. a., 9th	6:30 a. m., 11th.
				5	Ci. St.	w.			
	10	R, Y	Dim	2	Ci.	w.	Falling	D. N. a., 9th	6:30 a. m., 11th.
				7	Ci. St.	w.			
	10			7	Ci. St.	w.	Stationary		
	12			7	Ci. St.	w.	Stationary	8:15 a. m., 11th	6:14 a. m., 14th.
	13			5	Ci. St.	nw.	Stationary	8:15 a. m., 11th	6:14 a. m., 14th.
				4	A. St.	nw.			
	14			6	Ci. St.	nw.	Stationary	6:17 a. m., 14th	7:39 a. m., 15th.
				3	A. St.	nw.			
	16	R	Dim	8	Ci. St.	sw.	Stationary	6:40 p. m., 15th	10:50 a. m., 17th.
				2	St. cu.	w.			
	17	R	Dim	1	Ci.	sw.	Falling	6:40 p. m., 15th	10:50 a. m., 17th.
				5	Ci. St.	sw.			
	24			5	Ci. St.	sw.	Stationary	3:53 p. m., 17th	2:45 p. m., 26th.
	25	R	Dim	5	Ci. St.	w.	Falling	3:53 p. m., 17th	2:45 p. m., 26th.
				7	Ci. St.	w.			
	25	R, Y, B	Dim	2	A. St.	sw.	Stationary		
	26	R, O, Y	Bright	4	Ci. St.	ssw.	Falling	3:53 p. m., 17th	2:45 p. m., 26th.
				Few	Ci. cu.	ssw.			
	29			6	Ci.	w.	Falling	D. N. a., 27th	10:38 a. m., 4th.
	30	R, Y	Bright	2	Ci.	w.	Stationary	D. N. a., 27th	10:38 a. m., 4th.
				3	Ci. St.	w.			
Madison, Wis.	1	R	Dim	10	Ci. St.	w.	Stationary	9:00 p. m., 28th	11:00 p. m., 3d.
	1		Bright						
	2	R	Brilliant	10	Ci. St.	w.	Stationary	9:00 p. m., 28th	11:00 p. m., 3d.
	2	R	Bright	2	Ci. St.	w.			
	2	R	Dim	2	Ci. St.	w.			
	2	R	Brilliant	8	Ci. St.	w.			
	2								
	2	B, Y, R	Brilliant	2	Ci. St.	w.			
	3	W	Dim	10	Ci. St.	w.	Falling	9:00 p. m., 28th	11:00 p. m., 3d.
	6	R, Y, G, B	Bright	8	Ci.	w.	Stationary	5:50 p. m., 4th	D. N. a., 10th.
	7	R	Brilliant				Stationary	5:50 p. m., 4th	D. N. a., 10th.
	7	R	Brilliant						
	7	R	Brilliant						
	7	R	Brilliant						

*Aerological station.

† Beginning with part nearest sun or moon. R, red; O, orange; etc.

Halo phenomena observed during March, 1919—Continued.

Station.	Date.	Colors.†	Degree of brightness.	Clouds.			Station pressure.	Precipitation.	
				Amount.	Kind.	Direction.		Last previous ended.	First subsequent began.
Madison, Wis. (continued)	7	R	Brilliant						
	7	R	Brilliant						
	7		Bright						
	7	W	Brilliant						
	7	R	Brilliant						
	7		Dim						
	7		Dim						
	8	R	Bright	10	Ci. st.	w.	Falling	5:50 p. m., 4th	D. N. a., 10th.
	8	R	Brilliant						
	8	R	Bright						
	8	R	Brilliant						
	8		Dim						
	8	W	Brilliant						
	8		Dim						
	8		Bright						
	8		Dim						
	9	R	Bright	4	Ci. st.	w.	Rising	5:50 p. m., 4th	D. N. a., 10th.
	12	R	Bright	10	Ci.	w.	Falling	3.00 p. m., 10th	10:30 a. m., 13th.
					Ci. st.				
	12		Dim	3	Ci.	w.	Rising		
				7	Ci. st.	w.			
	16	R	Brilliant	10	Ci. st.	w.	Rising	12:15 p. m., 16th	8:00 p. m., 17th.
	16	R	Brilliant						
	16	W							
	16	W							
	16	W							
	16	W							
	16	W							
	21	R	Brilliant	Few.	Ci. st.	w.	Stationary	6:40 p. m., 20th	4:00 p. m., 25th.
	22	W		6	Ci.	w.	Stationary	6:40 p. m., 20th	4:00 p. m., 25th.
	22	R	Bright						
	22	R							
	23	W	Dim	10	Ci. st.	w.	Falling	6:40 p. m., 20th	4:00 p. m., 25th.
	23	R	Bright						
	24	R	Brilliant	10	Ci. st.	w.	Falling	6:40 p. m., 20th	4:00 p. m., 25th.
	24	R	Brilliant						
	25		Dim	4	Ci. st.	w.	Falling	6:40 p. m., 20th	4:00 p. m., 25th.
Nashville, Tenn	10	R, O, Y, G, B	Bright	7	Ci. st.	w.	Falling	9:50 p. m., 8th	1:30 a. m., 14th.
	12		Bright	10	Ci. st.		Stationary	9:50 p. m., 8th	1:30 a. m., 14th.
	25	R	Dim	7	Ci. st.	w.	Stationary	1:10 p. m., 17th	5:55 a. m., 26th.
Rochester, N. Y	8	R, O, Y	Brilliant	5	Ci. st.	sw.	Falling	2:30 p. m., 7th	12:35 a. m., 9th.
				5	A. st.				
	8	W	Brilliant						
	8		Dim						
	8		Dim						
	13	R	Dim	7	Ci.	w.	Rising	3:00 p. m., 13th	4:00 p. m., 15th.
				2	Ci. st.	nw.			
	13	W	Bright	9	Ci. st.	nw.			
Royal Center, Ind.*	3	R, O, Y, G, B	Bright	10	Ci. st.	w.	Falling	D. N. P., 28th	D. N. P., 4th.
	6	R	Dim	4	Ci. st.	nw.	Falling	D. N. a., 5th	4:02 p. m., 8th.
				5	St. cu.	nw.			
	7		Dim	10	A. st.	nw.	Rising	D. N. a., 5th	4:02 p. m., 8th.
	7		Dim	10	A. st.	nw.			
	12	R, O, Y, G, B	Bright	8	Ci. st.	w.	Stationary	2:40 p m., 10th	3:42 p. m., 13th.
	13								
	13	R	Dim	2	Ci. st.	w.	Falling		
				1	Ci. cu.	w.			
	24	R, B	Dim	6	Ci. st.	w.	Falling	1:15 p. m., 21st	D. N. a., 26th.
	25	R	Dim	8	Ci. st.	sw.	Falling	1:15 p. m., 21st	D. N. a., 26th.
Tatoosh Island, Wash	4	O, V	Bright	3	Ci. st.	w.	Rising	10:12 a. m., 4th	12:05 p. m., 4th.
				3	Cu.	w.			
	4	R, O, Y, B, V	Dim	2	Ci. st.	nw.	Rising	1:42 p. m., 4th	3:19 p. m., 4th.
				3	A. st.	w.			
				5	Ci.	w.			
	4	R, B	Dim	2	Cu.	w.			
				5	Ci.	w.			
	4	R, B	Dim	2	Cu.	w.			
	5	R, B	Dim	Few.	A. st.	w.	Falling	8:50 a. m., 5th	9:36 a. m., 5th.
				9	St.	e.			
	5	R, Y, B, V	Bright						
	6	W	Dim	1	Ci. st.	nw.	Rising	11:07 a. m., 6th	1:14 p. m., 6th.
				6	St. cu.	nw.			
	7	W	Dim	5	Ci. st.	nw.	Falling	10:10 a. m., 7th	11:49 a. m., 7th.
				5	St. cu.	s.			
	7	W	Dim						
	7	W	Dim						
	8			1	Ci. st.	sw.	Rising	6:30 a. m., 8th	1:24 p. m., 9th.
				1	Cu.				
	8	W	Dim						
	8	W	Dim						
	8	Y	Dim	Few.	Ci. st.	n.			
				Few.	St. cu.				
	9		Dim	Few.	Ci. st.	w.	Rising	6:30 a. m., 8th	1:24 p. m., 9th.
				6	St. cu.	sw.			
	11	W	Dim	1	Ci. st.	sw.	Rising	6:40 p. m., 11th	D. N. p., 12th.
				3	A. cu.	sw.			
	12	W	Dim	5	Ci.	s.	Falling	6:40 p. m., 11th	D. N. p., 12th.
				Few.	Cu.	se.			
	12	R, B, W	Dim	5	Ci.	s.			
				Few.	Cu.	se.			
	20	W	Dim	3	Ci. st.	nw.	Stationary	6:10 a. m., 18th	7:30 p. m., 22d.
				6	A. st.	w.			
	20	R, Y, B, W	Bright	1	Ci. st.	nw.			
				2	A. st.	w.			
	20	R, B, W	Bright	5	Ci. st.	nw.			
				3	A. st.	w.			
	21	W	Dim	2	Ci. st.	nw.	Falling	6:10 a. m., 18th	7:30 p. m., 22d.
	21	W	Dim	1	Ci. st.	nw.			
	21	W	Dim						

*Aerological station.

†Beginning with part nearest sun or moon. R, red, O, orange, etc.

Halo phenomena observed during March, 1919—Continued.

Station.	Date.	Colors.†	Degree of brightness.	Clouds.			Station pressure.	Precipitation.	
				Amount.	Kind.	Direction.		Last previous ended.	First subsequent began
Tatoosh Island, Wash. (continued)	21								
	22	W	Dim	2	Ci. st.	w.	Falling	6:10 a. m., 18th	7:30 p. m., 22d.
				1	A. st.	w.			
	22	W	Dim						
	22	W	Dim						
	22	R, Y, B	Bright	2	Ci. st.	sw.	Rising		
				4	A. st.	w.			
	22	W	Dim	2	Ci. st.	sw.			
				2	Ci. cu.	w.			
	22	W	Dim	6	Ci. st.	sw.			
	24	W	Dim	7	Ci. st.		Falling	D. N. p., 22d.	6:52 a. m., 27th.
	24	W	Dim	Few.	Ci. st.	nw.			
				Few.	St. cu.	sw.			
	24	R, Y, B	Bright	Few.	Ci. st.	nw.			
				Few.	St. cu.	sw.			
	24	R, Y, B	Bright						
	24	R, Y, B	Bright	Few.	Ci. st.	nw.			
				Few.	St. cu.	sw.			
	25	W	Dim	1	Ci. st.	nw.	Rising	D. N. p., 22d.	6:52 a. m., 27th.
				Few.	St. cu.	e.			
	25	R, B	Bright	1	Ci. st.	nw.			
				Few.	St. cu.	e.			
	25	R, B	Bright						
	25	W	Dim	1	Ci. st.	nw.			
				Few.	St. cu.	e.			
	26	R	Dim	2	A. st.	w.	Falling	D. N. p., 22d.	6:52 a. m., 27th.
	26	R, Y, B	Bright	7	Ci. st.	w.			
	26	R, Y, B	Bright	9	Ci. st.	w.			
	29	W	Dim	2	Ci. st.		Falling	D. N. p., 28th	D. N. a., 30th.
				7	St. cu.				
	29	R, B	Dim			se.			
	29	R, B	Dim						
	29	R, Y, B	Bright	3	Ci. st.	se.	Rising	D. N. p., 28th	D. N. a., 30th.
				6	St. cu.	se.			
	31	O	Dim	4	Ci. cu.	sw.	Falling	D. N. p., 30th	11:50 a. m., 3d.
				5	St. cu.	s.			
	31	O	Dim	2	Ci. st.	sw.			
				7	A. st.	sw.			
	31	W	Dim						
	31	R, O, Y, G, B, V.	Brilliant	Few.	Ci. st.	s.			
				9	A. st.	s.			
York, N. Y.	4	O	Dim	8	A. st. / St. cu.	s.	Falling	D. N. a., 1st	8:00 a. m., 5th.
	9	O	Dim	2	A. st.	sw.	Falling	11:00 a. m., 9th	4:15 p. m., 9th.
				8	St.				
	10	W	Bright	3	Ci. st.	w.	Rising	4:30 p. m., 9th	D. N. p., 10th.
	11	R, Y	Dim	4	Ci. st	w.	Stationary	D. N. a., 11th	1:00 p. m., 11th.

† Beginning with part nearest sun or moon. R, red; O, orange; etc.

NOTES.

As indicated in the table, unusually brilliant halo phenomena were observed in different parts of the country on March 7 and 8, 1919, particularly in the north-central States. At Drexel, Nebr., on the 8th, the measured distance of parhelia from the sun was 28°, the altitude of the sun at the time, 10:09 a. m., being 33°.

At Madison, Wis., there were visible at noon on the 7th halos of 22° and 46°, parhelic circle, paranthelia of 120°, parhelia, and a complete circumscribed halo. Early on the 7th and 8th there were also seen brilliant upper tangent arcs and a circumzenithal arc. This upper arc was so bright that a lady in Milwaukee reported by telephone to the local Weather Bureau office that she saw the "sun" overhead at 10 a. m.

Similar displays are described in special reports by Mr. Patrick Connor, meteorologist, Kansas City, Mo., and Mr. A. D. Sanial, assistant observer, La Crosse, Wis. At Kansas City the forms observed included halos of 22° and 46°, parhelia, upper tangent arcs and circumzenithal arc; at La Crosse, halo of 22°, parhelia, upper and lower tangent arcs, and parhelic circle.

SOLAR AND SKY RADIATION MEASUREMENTS DURING MARCH, 1919.

By HERBERT H. KIMBALL, Professor of Meteorology, in Charge.

[Dated: Solar Radiation Investigations Section, Washington, Apr. 29, 1919.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1919, **47**:4.

The monthly means and departures from normal in Table 1 show that solar radiation intensities averaged above the normal at Washington, close to normal at Lincoln, and below normal at Madison.

Table 3 shows deficiencies in the total radiation for the month as compared with the March normals, amounting to about 7 per cent at Washington and Lincoln, and 10 per cent at Madison.

Skylight polarization measurements obtained on 6 days at Washington give a mean of 63 per cent, with a maximum of 66 per cent on the 12th. These are average values for Washington in March. At Madison the ground was covered with snow until the 12th. Skylight polarization measurements obtained on five days during the last half of the month give a mean of 60 per cent, with a maximum of 65 per cent on the 18th. These are low values for Madison in March.

TABLE 1.—*Solar radiation intensities during March, 1919.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Mar. 1	.....	.....	1.26	1.18	1.11	1.04	0.98	.....	.....	.....
7	.....	1.11	.....	0.89	0.80	0.77	.....	.....	.....	.....
10	.....	.....	1.27	1.22	.....	.....	0.84	.....	.....	.....
12	.....	1.34	1.16	1.02	0.89	0.77	0.70	0.68	0.66	.....
18	.....	1.27	1.22	1.18	.....	.....	.....	.....	.....	.....
20	.....	1.26	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	1.32	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	1.27	1.21	1.09	1.00	0.92	.....	.....	.....	.....
28	.....	.....	1.36	.....	.....	1.04	.....	.....	.....	.....
29	.....	.....	1.14	1.04	0.96	.....	0.79	0.73	0.71	.....
31	.....	1.25	.....	1.01	0.93	.....	.....	.....	.....	.....
Monthly means	.....	**1.26**	**1.23**	**1.08**	**0.95**	**0.91**	**0.83**	**(0.70)**	**(0.68)**	.....
Departures from 11-year normal	.....	**−0.02**	**+0.07**	**+0.02**	**±0.00**	**+0.04**	**+0.03**	**−0.04**	**−0.03**	.....
P. M.										
Mar. 6	(*1.49)	1.37	1.24	1.13	1.02	0.92	0.84	0.77	0.71	0.65
7	.....	1.10	0.89	.....	.....	.....	.....	.....	.....	.....
12	(*1.51)	1.41	1.29	1.17	1.05	0.95	0.88	0.82	0.77	0.72
21	.....	1.34	1.17	1.10	1.05	1.00	0.94	.....	.....	.....
22	.....	1.32	1.27	1.20	1.15	1.10	1.05	1.02	.....	.....
24	.....	1.37	1.26	1.17	1.07	0.98	0.94	0.88	0.82	.....
25	.....	1.00	0.87	.....	.....	.....	.....	.....	.....	.....
29	.....	1.35	1.24	1.16	1.06	0.97	0.96	0.93	0.90	.....
Monthly means	.....	**1.28**	**1.15**	**1.16**	**1.07**	**0.99**	**0.94**	**0.88**	**0.80**	**(0.68)**
Departures from 11-year normal	.....	**−0.01**	**+0.02**	**+0.13**	**+0.13**	**+0.13**	**+0.13**	**+0.12**	**+0.10**	**+0.03**

* Extrapolated, and reduced to mean solar distance.

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Mar. 5	.....	1.43	1.38	1.33	1.25	1.19	1.12	1.03	.....	.....
11	.....	1.51	.....	.....	.....	.....	.....	.....	.....	.....
12	.....	.....	1.26	1.18	1.12	1.05	.....	.....	.....	.....
18	(*1.49)	.....	1.31	1.22	1.15	1.07	1.00	0.94	.....	.....
19	.....	1.31	1.16	.....	.....	.....	.....	.....	.....	.....
21	.....	1.46	1.36	1.28	1.17	.....	.....	.....	.....	.....
22	.....	1.38	.....	.....	.....	.....	.....	.....	.....	.....
28	.....	.....	1.17	.....	.....	.....	.....	.....	.....	.....
Monthly means	.....	**1.42**	**1.27**	**1.23**	**1.17**	**1.10**	**(1.06)**	**(0.98)**	.....	.....
Departures from 9-year normal	.....	**−0.02**	**−0.06**	**−0.02**	**−0.03**	**−0.04**	**±0.00**	**−0.07**	.....	.....
P. M.										
Mar. 5	.....	1.43	1.33	1.23	1.13	.....	.....	.....	.....	.....
19	.....	1.32	1.21	1.07	0.94	.....	.....	.....	.....	.....
21	.....	1.45	1.28	.....	1.07	1.01	0.94	.....	.....	.....
27	.....	.....	.....	1.25	1.20	.....	.....	.....	.....	.....
Monthly means	.....	**1.40**	**1.27**	**1.18**	**1.08**	**(1.01)**	**(0.94)**	.....	.....	.....
Departures from 9-year normal	.....	**−0.03**	**−0.08**	**−0.08**	**−0.11**	**−0.18**	**−0.13**	.....	.....	.....

Lincoln, Nebr.

A. M.										
Mar. 1	.....	1.42	1.26	1.12	.....	.....	.....	.....	.....	.....
10	.....	1.48	1.30	1.10	.....	.....	.....	.....	.....	.....
11	(*1.56)	1.45	1.35	1.25	1.16	1.07	.....	.....	.....	.....
16	.....	1.43	.....	.....	.....	.....	.....	.....	.....	.....
17	.....	1.46	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	1.37	.....	.....	.....	.....	.....	.....	.....	.....
19	.....	.....	.....	.....	0.98	0.87	0.82	.....	.....	.....
21	.....	1.22	.....	.....	.....	.....	.....	.....	.....	.....
28	.....	1.27	1.17	1.08	.....	.....	.....	.....	.....	.....
31	(*1.48)	1.35	1.24	1.13	1.06	0.95	0.87	.....	.....	.....
Monthly means	.....	**1.38**	**1.26**	**1.14**	**1.07**	**0.96**	**(0.84)**	.....	.....	.....
Departures from 4-year normal	.....	**−0.01**	**−0.06**	**−0.08**	**−0.04**	**−0.05**	**−0.07**	.....	.....	.....
P. M.										
Mar. 10	.....	1.51	1.42	1.28	1.21	1.14	1.08	1.02	0.96	0.90
11	.....	.....	1.33	1.28	1.17	1.11	1.05	0.99	0.94	0.89
12	.....	.....	.....	.....	.....	.....	.....	0.86	0.81	.....
17	.....	1.40	1.28	1.16	1.13	1.05	1.00	0.92	0.85	0.78
18	(*1.48)	1.36	1.23	1.12	1.01	0.92	0.83	0.75	0.70	0.65
29	.....	.....	.....	.....	0.82	0.73	.....	.....	.....	.....
31	.....	1.37	1.27	1.16	1.07	0.98	0.91	.....	.....	.....
Monthly means	.....	**1.41**	**1.31**	**1.20**	**1.07**	**0.99**	**0.97**	**0.91**	**0.85**	**0.80**
Departures from 4-year normal	.....	**+0.02**	**+0.03**	**+0.01**	**−0.02**	**−0.02**	**+0.01**	**+0.02**	**+0.02**	**−0.01**

* Extrapolated, and reduced to mean solar distance.

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1919.	*mm.*	*mm.*	1919.	*mm.*	*mm.*	1919.	*mm.*	*mm.*
Mar. 1	4.75	3.30	Mar. 5	0.71	1.07	Mar. 1	1.02	1.60
6	3.30	3.30	11	2.36	3.81	10	3.63	3.45
7	3.81	4.57	12	4.37	5.16	11	3.30	5.56
10	3.63	3.99	18	3.15	4.17	12	4.17	5.36
12	3.63	3.45	19	4.17	6.50	16	3.81	4.17
18	5.56	4.75	21	2.06	3.15	17	4.37	4.17
20	6.76	5.56	22	3.00	2.62	18	3.99	6.02
21	5.56	7.29	27	2.36	2.62	19	4.37	7.29
22	3.99	3.00	28	2.62	3.30	21	2.16	5.16
24	3.15	3.30	.....	.....	.....	28	4.37	7.87
25	3.30	4.37	.....	.....	.....	29	6.50	9.14
28	2.49	1.88	.....	.....	.....	31	3.63	3.00
29	2.26	1.88	.....	.....	.....	.....	.....	.....
31	2.36	3.00	.....	.....	.....	.....	.....	.....

TABLE 3.—*Daily totals and departures of solar and sky radiation during March, 1919.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Mar. 1	368	308	314	76	21	− 28	76	21	− 28
2	372	385	413	77	94	67	153	115	39
3	362	252	351	64	− 42	1	217	73	40
4	357	88	237	56	−210	−117	273	−137	− 77
5	63	445	443	−241	143	85	32	6	8
6	441	329	221	134	23	−141	166	29	−133
7	397	275	196	86	− 35	−170	252	− 6	−303
8	292	265	356	− 22	− 49	− 14	230	−55	−317
9	208	387	123	−109	69	−251	121	14	−568
10	426	234	528	106	− 88	150	227	−74	−418
11	276	462	532	− 48	136	150	179	62	−268
12	466	400	430	139	70	44	318	132	−224
13	320	49	218	− 10	−285	−172	308	−153	−396
14	77	89	110	−256	−249	−284	52	−402	−680
15	53	73	208	−283	−269	−190	−231	−671	−870
16	71	226	509	−267	−120	108	−498	−791	−762
17	278	144	552	− 62	−206	149	−560	−997	−613
18	475	478	554	132	124	148	−428	−873	−465
19	233	475	499	−112	117	91	−540	−756	−374
20	435	389	295	88	27	−115	−452	−729	−489
Decade departure							−679	−655	− 71
21	454	537	489	105	171	77	−347	−558	−412
22	226	505	332	−125	135	− 82	−472	−423	−494
23	492	442	524	139	68	108	−333	−355	−386
24	45	418	145	−310	40	−273	−643	−315	−659
25	480	190	112	123	−192	−308	−520	−507	−967
26	160	157	433	−200	−228	12	−720	−735	−955
27	140	526	458	−222	137	36	−942	−598	−919
28	460	515	502	95	122	79	−847	−476	−840
29	480	251	500	113	−145	76	−734	−621	−764
30	360	97	217	− 10	−303	−208	−744	−924	−972
31	400	348	635	28	− 56	209	−716	−980	−763
Decade departure							−264	−251	−274
Excess or deficiency since first of year							−512	−2,344	−1,349
							− 2.3	− 10.7	− 5.1

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By DR. C. G. ABBOT.

[Dated: Washington, D. C., Apr. 17, 1919.]

In continuation of the publication begun last month, I communicate the following results of the measurements of the solar constant of radiation which were made by the Smithsonian observers, Messrs. A. F. Moore and L. H. Abbot, at Calama, Chile, in the month of February, 1919.

The arrangement of the observations in the table is the same as that employed in the preceding communication, and is fully explained in the MONTHLY WEATHER REVIEW for February, 1919, **47**:85–87.

Since my last communication, I have received from the observers notes covering their observations of the cloudiness on every day since they have been in Calama. They are disappointed by the unexpected amount of cloudiness encountered, since daily reports of cloudiness at Calama as furnished in manuscript by Dr. Walter Knoche for the years 1913 and 1914 had indicated that more than 200 days in the year would be found absolutely cloudless there. This is very far from being the case in the years 1918 and 1919. I am inclined to think, however, that these years are exceptional over a large portion of the earth. For instance, at Mount Wilson in 1918 the number of suitable observing days for solar constant purposes was very much less than usual, and reports of the same general tendency have come from other regions.

The following table summarizes the results of observations of cloudiness at Calama. The observers reached the station June 19, and began solar constant observations July 27, 1918.

Cloudiness and observing at Calama.

Month.	Number of days.						
	Total.	Observed.	Available.	All cloudless.	Half day cloudless.	Few clouds.	Generally cloudy.
1918.							
June	12	.....	.....	1	.....	2	9
July	31	5	5	18	.....	5	8
August	31	27	31	10	9	10	2
September	30	18	30	3	2	12	13
October	31	24	31	5	4	11	11
November	30	23	30	3	6	11	10
December	31	19	31	3	7	10	11
1919.							
January	31	19	31	1	5	12	13
February	28	20	28	1	6	13	8
Total	255	155	217	45	39	86	85

$\frac{\text{Observed}}{\text{Available}} = 0.715.$ $\frac{\text{Cloudless + half days cloudless + few clouds}}{\text{Total number of days}} = 0.667.$

Solar radiation observations.

Date.	Solar Const.	Grade.	Transmission coefficient at 0.5 microns.	Humidity, air mass 3.			Remarks.
				ρ/ρ_{sat}	V. P.	Rel. Hum.	
P. M.	*cal.*				*cm.*	%	
Feb. 3....	1.949	VG	0.861	0.358	0.53	24	Considerable cirrus and cumulus in east, south and north.
A. M.							
6....	1.946	E−	.852	.327	.39	32	Cloudless except cirri along eastern horizon.
7....	1.931	E−	.863	.452	.36	32	
8....	1.976	VG	.861	.512	.31	30	
9....	1.971	E−	.856	.473	.37	46	
10....	1.908	E−	.852	.482	.48	53	
11....	1.909	VG	.850	.446	.37	39	Thin cirri scattered over sky.
12....	1.961	VG−	.846	.351	.58	56	Cirri in west and east.
13....	1.957	VG+	.831	.323	.60	57	Few cumuli in south and west.
14....	1.952	VG−	.841	.373	.66	66	
15....	1.915	VG−	.830	.328	.74	70	Long bank of cirrus in east.
16....	1.944	VG−	.831	.357	.64	66	Cirri in north and west, disappearing in east.
17....	1.973	E−	.857	.394	.49	52	Cloudless except small cumuli disappearing in west.
18....	1.938	VG	.857	.452	.49	46	
19....	1.961	VG+	.837	.511	.35	31	Thin cirri on northern and eastern horizon.
22....	1.933	VG+	.862	.500	.35	32	Cirrus in west early in morning.
P. M.							
24....	1.974	VG	.851	.441	.49	19	Cirri and some cumuli in north, east, and south.
A. M.							
25....	1.936	VG+	.861	.449	.36	29	Thin cirri scattered about north and west, and moving east.
P. M.							
26....	1.915	E	.865	.427	.32	29	
27....	1.891	G−	.844	.317	.75	37	Bank of cumulus in east. Cumuli scattered in other quarters.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

GENERAL CONDITIONS.

By A. J. HENRY, Meteorologist.

The distribution of normal pressure over the Northern Hemisphere for March differs but slightly from that of February except that there is a rather pronounced fall over the great Continental Highs amounting to as much as 0.20 inch in Siberia and about half that much on the North American Continent. Normal pressure, February to March, increases in the polar regions, especially over Greenland and oceanic areas southward therefrom to 45 degrees N. latitude.

The pressure distribution of the current month was mostly in accordance with the normal. Stormy weather was experienced locally over portions of the oceanic areas and over continental areas a few storms of tornadic violence were reported; otherwise seasonal weather was experienced.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

As indicated in the report of conditions for February, a storm of some importance appeared to be developing in the region immediately to the eastward of Japan at the close of the month. Subsequent reports have confirmed this. During the period from Feb. 23–28 winds as high as force 12 were experienced within the area between the 140th and 165th meridians, east longitude, and the 30th and 40th parallels.

The weather continued generally stormy within this area during the first week of March, winds of gale force being reported from some point every day until the 8th, inclusive. East of the 165th meridian quiet conditions prevailed, with only occasional gales, of moderate force, mostly from a westerly direction.

During the second week of the month storm conditions gradually progressed to the eastern part of the ocean, where, from the 11th to the 15th, winds of gale force prevailed very generally.

After the 8th the western part of the ocean was relatively free from storms, only one having thus far been reported. This appears to have been of limited extent but of considerable intensity. It occurred on the 20th and 21st in the region lying between the 160th and 170th meridians and near the 35th parallel. Two vessels, the Japanese steamships *Darien Maru* and *African Maru* which encountered this gale, report winds of force 10, with tremendous seas.

Altogether, winds of gale force were reported by different vessels for a total of 47 times during the month, as follows: Force 7, 29 times; force 8, 10 times; force 9, 2 times; force 10, 5 times; force 11, once.

No reports have been received to indicate that any unusual conditions or noteworthy phenomena occurred on the North Pacific Ocean during the month.

NORTH AMERICA.

By A. J. HENRY, Meteorologist.

The temperature in the eastern portions of the United States and Canada was mild for the season, thus maintaining the characteristics of the previous month; and the winter as a whole must be classed as a mild one. The temperature in the northern tier of States west of the upper Lakes was below the seasonal normal and also to a greater or less extent in the Rocky Mountain region and thence westward to the coast.

Precipitation was generally ample in amount and well distributed both in time and space. The snow cover was decidedly less than the average, except in the higher altitudes of the Rocky Mountain region.

Severe local storms and tornadoes occurred, but their number was not in excess of the normal expectancy.

Severe floods were entirely absent and the usual spring rise in the rivers in northern districts was distinctly affected by the absence of any considerable snow cover.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The general atmospheric conditions for March, 1919, showed a decided contrast to those of the previous month when the average pressure was considerably below the normal. For the month under discussion the mean barometric readings at a number of stations on the Atlantic and Gulf coasts were above the normal, the same conditions holding true at the Azores and Bermudas. Not enough vessel reports were received in time to determine accurately the average pressure over the different divisions of the ocean, although from an examination of those at hand it is evident that over the steamer lanes the pressure was also higher than usual.

The number of days on which gales occurred was apparently not far from the normal over the greater part of the ocean, except that in the western part of the steamer lanes they seemed to be slightly more frequent than usual.

On March 1 a LOW was central in the vicinity of latitude 45°, longitude 30°, and moderate to strong westerly and northwesterly gales prevailed over the area between the 38th and 45th parallels and the 35th and 55th meridians, accompanied by rain and hail over the eastern section. During the next four days this disturbance moved eastward with a fairly uniform rate, diminishing gradually in intensity, and on the 5th the center was near Brest, France.

On the 4th there was a well-developed LOW near latitude 43° and longitude 53° (See chart IX. The cyclonic movement of the wind was very marked, and southerly gales of from 40 to 60 miles were reported from the easterly quadrants, while northerly winds of about the same force prevailed west of the center. This disturbance drifted slowly eastward, and on the 5th was central near latitude 43°, longitude 43°, the storm area having contracted slightly since the previous day.

From the 6th to the 8th the circulation of the air, for the most part, was comparatively sluggish, and unusually high pressure prevailed over the western division of the ocean. On the latter date, however, one vessel near latitude 55°, longitude 27°, reported a westerly gale the morning of the 9th westerly gales were encountered in of about 50 miles an hour, accompanied by "hail." On mid-ocean, north of the 45th parallel, and while no storm reports were received from vessels off the American coast, the anemometer at New York registered a velocity of 48 miles an hour from the east, with a maximum force of 56 miles during the night of the 8th.

On the 10th there was a well-developed LOW central near Halifax, N. S., where the barometer reading was 29.40 inches, while at St. Johns, Newfoundland, it read 30.24

inches, at Norfolk, Va., 30.14 inches, and at a point near latitude 41°, longitude 56°, 30.20 inches. The steep gradient was responsible for winds of gale force at different points along the American coast between Newfoundland and Georgia. On the 11th the center of this LOW was near St. Johns where the barometer had fallen to 29.40 inches since the previous day; the wind had diminished in force, and was light to moderate.

On the 12th moderate gales were reported about 8° east of Bermuda, and also over the eastern part of the steamer tracks.

On the 13th a point near latitude 45°, longitude 41°, was the center of a violent disturbance. (See chart IX.) The Danish steamer *Helig Olaf*, reported that at 5:15 p.m., March 13, while near latitude 47°, 45′, longitude 38°, 50′, the barometer reading was 28.87 inches, and the wind blowing with hurricane force from the southwest, shifting shortly afterward to the northwest. On that day reports were received from vessels between the 35th and 50th parallels and 35th and 60th meridians, showing that winds of gale force were prevalent over a large part of that region. This LOW moved rapidly northeastward, and on the 14th, the center was near latitude 55°, longitude 30°; the storm area had contracted since the previous day, although southwesterly winds of from 40 to 65 miles an hour were still encountered between the 45th and 55th parallels, and the 30th and 40th meridians.

From the 15th to the 20th moderate weather prevailed, the pressure being comparatively high over the entire ocean, except that on the 19th and 20th readings of less than 30 inches were recorded by vessels near the European coast, and also at the British and French meteorological stations.

From the 21st to the 24th a few scattered reports were received from vessels along the American coast, denoting moderate northeasterly gales, while these were interspersed with many that experienced winds of less than gale force, some of them also reporting fog. On the 21st the barometric reading at St. Johns, N. F., was 30.50 nches and at Bermuda, 29.70 inches. However, the unusually steep gradient, and the complete reversal of the normal distribution of pressure, seemed to have little effect on the general weather conditions in the intermediate region where only light to moderate winds prevailed.

By the 25th, the barometer at St. Johns had fallen to 29.20 inches, and the center of a well-developed LOW was about 250 miles south of that point, while northwesterly gales, with snow, were encountered by vessels in the southwest quadrants. This disturbance remained nearly stationary during the next 24 hours, and on the 26th westerly winds of gale force were encountered between the 35th and 45th parallels and the 55th and 60th meridians.

From the afternoon of the 27th to the morning of the 30th an exceptionally severe storm swept the American coast between Hatteras and Nantucket. The observer on the American steamship *Amolco* stated in the storm-log that the lowest barometer reading was 29.35 inches at 6 p. m., on the 27th, when the vessel was near latitude 35° 8′, longitude 73° 21′, and at 11:45 p. m. on that date the wind shifted from south to northwest, and remained in that quarter until the end of the storm on the 30th, while the highest velocity of the wind was 57 miles an hour. The Dutch steamship *Bawean*, first ran into this blow on the 28th, and the lowest barometer reading was 29.15 inches at 1 a. m. March 29, latitude 35° 6′, longitude 69° 14′; highest velocity of the wind 55 miles an hour. with no shifts. At the time of observation on the morning of the 28th, northwest gales of from 50 to 65 miles an hour, accompanied by snow in the northern portions, swept the coast between Hatteras and New York, and the anemometer at the latter station registered a maximum velocity of 93 miles an hour, during the night of the 28th. On the morning of the 29th, the storm still maintained its force, and did not begin to diminish appreciably until the 30th, and even on that day moderate gales were reported between the 35th and 40th parallels, and the 60th meridian and the American coast. (See chart IX.)

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

FLOODS IN BRAZIL.

Rio de Janeiro, March 18, 1919.—"Various localities in Brazil are suffering from floods. The town of Joazeiro, State of Bahia, is inundated and thousands of houses have been wrecked by the water. The rivers in various parts of the republic are above flood stage and considerable damage is resulting."—*Associated Press.*

BRITISH WEATHER, MARCH, 1919.

A large anticyclone maintained a fairly normal position over the south of the North Atlantic, but at frequent intervals there was a second high-pressure system, sometimes in the Icelandic region, at other times over northern Europe. In these circumstances, the British Isles were exposed to numerous disturbances.

In the first 10 days of March rains were generally heavy; at Greenwich, in the three days ending March 5, the rainfall measured 1.49 inches, which is 0.03 inch more than the 60 years' average for the whole month.

The second half of the month was much colder than the first, the difference being 7° F. at Greenwich. Between the 23d and 26th, sharp frosts were experienced in all districts; and on the night of the 28th–29th the heaviest snowstorm of the winter occurred, the snowfall exceeding a foot in parts of southern England.

The general rainfall expressed as a percentage of the average was: England and Wales, 196; Scotland, 105; Ireland, 112.—*Symons's Meteorological Mag., Apr., 1919, p. 33; and Nature (London), Mar. 13, p. 30, and Apr. 3, 1919, p. 90.*

CYCLONES AND ANTICYCLONES.

By EDWARD H. BOWIE.

Of the LOWS that were charted for March, 1 was of the Alberta type, 2 North Pacific, 3 Colorado, 1 Texas, 2 Central, and 1 (No. 12) of semitropical origin. There were 3 Alberta cyclones fewer than usual, but 3 cyclones more than usual originating in the center and south.[1]

Of the HIGHS that were charted, 5 were of the Alberta type, 4 North Pacific, and 2 Hudson Bay. As compared with the average, 1892–1912, there were 3 extra North Pacific and 1 extra Hudson Bay HIGHS.[2]

It will be noted that there was a general tendency of LOWS to move east-southeastward until the 100th meridian was reached and afterwards to move almost due northeast, the regularity of this movement in practically all instances being one of the striking features of the storm movements of March, 1919. The HIGHS moved almost invariably eastward until the 90th meridian was reached, but east of the 90th meridian a number of them moved southeastward to the South Atlantic States; the others continued their eastward march to the north Atlantic coast.

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, May 1, 1919.]

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds for March, 1919, are graphically shown on Chart VII, while the means at the several stations, with the departures from the normal, are shown in Tables I and III.

The average pressure for the month was above the normal over all portions of the United States, save for a small area in the northern Rocky Mountain and Plateau regions, and likewise over Canada as far northward as observations extended. The excess in pressure was most pronounced over the Lake region and thence eastward to the Canadian Maritime Provinces, due mainly to unusually high pressure for the season of the year over those regions about the middle of the month, and again during the early part of the last decade. In the southern and far western districts the average pressure was only slightly higher than normal and, as indicated above, there were slight negative departures in portions of the far Northwest.

The prevailing high pressure in the northern districts from the Great Plains eastward favored northerly winds over most eastern districts. From Texas westward and northwestward over the Plains, Rocky Mountain, and Plateau regions they were mostly from southerly quadrants, while along the Pacific coast they were mainly from the west.

The most notable feature of the winds during the month was the persistence of high velocities in connection with a storm that moved from the Gulf States northeastward to the New England coast near the latter part of the month. During this period winds of gale force, mostly from the Northwest, prevailed for days over the Middle and North Atlantic States, continuing long after the general barometric gradients had lessened to such an extent as to justify the expectation that the winds would have diminished greatly in force.

TEMPERATURE.

At the beginning of the month cold weather prevailed generally over the central valleys and the Northwest, while elsewhere temperatures were near, and in some sections considerably above, the seasonal average. Rapid changes to warmer or colder marked the weather during the greater part of the first decade, although toward the end more stable conditions prevailed. The early part of the second decade was mainly cold over the northern districts, particularly in the more eastern portions, but in the South and far West temperatures were mostly seasonable.

At the beginning of the third decade high pressure overspread the Northwest and there was a decided fall in temperature in those regions, but a quick return to warmer followed, although moderately cool weather continued over the northern districts from the Lake region eastward during much of the decade. In other portions of the country temperatures during the last decade of the month were uniformly near the seasonal average.

For the month as a whole the temperature was decidedly below the average over much of Montana and North Dakota and slightly below from Texas westward and northwestward to the Oregon coast. Over the remaining districts the monthly averages were above normal, but not decidedly so over any extensive areas.

Sharp contrasts in departures within relatively short distances appear in the Northwest where, over portions of central Wyoming, the monthly averages were as much as 7° above normal while in the adjoining State of Montana they were from 6 ° to 9 ° below. In southern Utah and portions of adjoining States the average temperatures were again below normal—a condition that has persisted for each of the five months, November to March, inclusive.

PRECIPITATION.

The month opened with a general storm area passing over the more eastern districts, rain still continuing in portions of New England, and light snows falling locally from the upper Lakes westward to and including the northern mountain districts, and general rains over Oregon and Washington. The weather promptly cleared over most districts and fair weather ruled until about the middle of the first decade, when rain or snow overspread most central and eastern districts and portions of the far West. Rains were fairly heavy and general near the end of the decade from the west Gulf States northeastward, some unusually heavy falls occurring at points in Alabama and Georgia.

The first half of the second decade was mainly without precipitation, but by the middle a well-developed storm had moved into the Missouri Valley and precipitation had

[1] Cf. Mo. Wea. Rev. Suppl. 1, 1914.
[2] Cf. Mo. Wea. Rev. Suppl. 4, 1917.

occurred over wide areas in the central, northern, and western portions of the country. At the same time local heavy rains, amounting to nearly 10 inches in 24 hours, had fallen in extreme southern Florida, causing heavy damages to trucking interests. The eastward progress of this storm brought considerable snow to the more northern districts, and in conjunction with an offshoot that developed in the middle Mississippi Valley heavy rains occurred over wide areas from the central valleys eastward. In portions of western Tennessee the 24-hour precipitation on the 16th and 17th was the heaviest ever known in that region, exceeding 10 inches at a number of points and causing much damage by washing and flooding. (See pp. 189–190 below.)

Following the passage of this storm there was generally but little precipitation over the western districts during the remainder of the month. This was particularly noticeable in the far Northwest, where rain had been of almost daily occurrence during the first two decades.

In the central districts rain again set in about the middle of the last decade and gradually extended eastward, developing into a severe storm with high winds and heavy precipitation over the more eastern districts from the 27th to near the end of the month.

For the month as a whole precipitation was generous and sufficient for all needs over the greater part of the country, although the amounts were slightly below normal over most of the Gulf States and from the Rocky Mountains westward, save in portions of New Mexico, Arizona, and adjacent States. From the middle and upper Mississippi Valleys eastward to the Atlantic coast the monthly precipitation was very generally above normal but usually by rather small amounts, save in portions of the middle Mississippi and lower Ohio Valleys, where large excesses were recorded. Precipitation was unusually heavy also over the greater part of New Mexico and other portions of the Southwest, where drought conditions have persisted for many months.

SNOWFALL.

While snow occurred at some period of the month over the greater part of the country, the amounts were usually small in the central and eastern districts. However, considerable snow occurred in the vicinity of Lake Michigan during the first decade and at points in northern New York and New England near the end of the month. In the mountain districts of the West the snowfall was unusually heavy in portions of New Mexico and the adjoining States and there were substantial additions to the amounts that had accumulated in the higher elevations of California and Oregon. Elsewhere the amounts received during the month were moderate but on the whole the outlook for a sufficient supply of water for the coming summer was very generally improved. This is particularly true in portions of the southern Mountain districts where the heavy snows have assured an abundant supply of water, but they were nevertheless severe on stock, causing heavy losses.

By the close of the month the snow cover had disappeared from practically all the country east of the Rocky Mountains, save in extreme northern New England and over a narrow strip along the northern border from Lake Superior westward. In the far West no snow remained at the lower elevations.

RELATIVE HUMIDITY.

From the Mississippi River eastward the relative humidity averages were nearly everywhere less than normal, and by substantial amounts at points in the Gulf States and Appalachian Mountain districts. To westward of the Mississippi the relative humidity was mostly above normal, by moderate amounts, although small areas in the northern Rocky Mountain and northern Plateau regions had well-marked negative departures.

SEVERE STORMS.

On the afternoon of the 5th severe storms occurred at points in the Middle Gulf States, particularly in Alabama, Georgia, and northern Florida. These were of tornadic character at several points, notably at Eufaula, Ala., where four persons were killed, others severely injured, and much property loss was sustained. Two persons were also killed at Lumpkin, Ga., and much damage to property resulted from the high winds.[1] On the 15th tornadoes or other severe storms were reported from points in Arkansas, Iowa, Kansas, and Nebraska, causing large property damage but without much loss of life.[2] The high winds over the Atlantic Coast States near the end of the month caused some damage to trees and the less substantial buildings.

Average accumulated departures for March, 1919.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	In.	In.	In.	P.ct.		P.ct.	
New England	37.2	+4.5	+12.7	4.16	+0.4	+2.1	6.5	+0.8	76	+1
Middle Atlantic	44.1	+4.1	+11.9	3.82	+0.2	−0.7	5.5	−0.2	69	−4
South Atlantic	55.9	+2.0	+ 4.1	2.78	−1.5	−2.0	5.1	+0.2	73	−2
Florida Peninsula	71.8	+1.5	− 0.6	4.99	+2.7	+2.7	4.3	+0.6	74	−4
East Gulf	58.8	+1.6	+ 0.5	5.26	−0.6	+2.3	4.6	−0.5	68	−7
West Gulf	57.8	−0.1	− 0.1	2.76	−0.4	−0.5	5.1	0.0	73	+1
Ohio Valley and Tennessee	46.2	+2.3	+ 7.3	5.46	+1.0	−1.9	5.2	−0.9	68	−4
Lower Lakes	35.8	+2.9	+13.4	3.08	+0.4	−2.2	5.8	−0.7	72	−4
Upper Lakes	31.3	+3.8	+16.4	2.61	+0.3	−1.0	5.7	−0.3	77	−1
North Dakota	18.2	−2.6	+13.8	1.12	+0.2	0.0	5.6	+0.1	86	+8
Upper Mississippi Valley	39.6	+3.6	+15.1	2.70	+0.3	−0.7	5.6	−0.1	74	0
Missouri Valley	39.8	+3.7	+16.9	1.60	−0.3	−0.4	5.4	−0.1	74	+4
Northern slope	30.9	+0.1	+10.2	0.68	−0.4	−0.7	5.6	+0.2	68	0
Middle slope	44.3	+1.8	+ 7.0	1.36	−0.1	+0.1	5.8	+1.1	68	+7
Southern slope	52.7	−0.5	− 3.0	2.77	+1.8	+1.6	4.6	+0.3	59	+5
Southern Plateau	48.0	−3.0	− 9.2	0.87	+0.4	−0.3	3.3	−0.4	49	+8
Middle Plateau	40.4	−0.5	− 1.0	0.79	−0.5	−1.1	5.1	+0.1	59	+1
Northern Plateau	42.1	+1.8	+ 7.4	1.36	−0.2	0.0	6.4	+0.6	64	−2
North Pacific	45.7	+0.8	+ 3.9	4.41	−0.3	+2.4	6.8	+0.2	80	+1
Middle Pacific	49.3	−2.0	− 2.3	3.41	−0.8	+0.7	5.3	0.0	77	+2
South Pacific	53.9	−1.6	+ 1.1	2.11	−0.5	−2.5	4.7	+0.1	71	0

[1] An account, with a map, of this storm will appear in the April REVIEW.
[2] See pp. 167–168 above.

Winds of 50 mis./hr. (22.4 m./sec.) or over, during March, 1919.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
		mi./hr.				mi./hr.				mi./hr.				mi./hr.	
Asheville, N. C.	8	50	e.	Evansville, Ind.	17	58	sw.	New York, N. Y.	28	92	nw.	Point Reyes Light, Calif.	8	61	nw.
Block Island, R. I.	28	70	nw.	Fort Smith, Ark.	16	58	sw.	Do.	29	87	nw.	Do.	12	62	se.
Do.	29	60	nw.	Hannibal, Mo.	16	50	sw.	Do.	30	50	nw.	Do.	13	58	sw.
Do.	30	50	nw.	Hatteras, N. C.	26	50	nw.	Norfolk, Va.	27	52	nw.	Do.	14	58	nw.
Buffalo, N. Y.	1	76	sw.	Do.	27	51	nw.	Do.	28	56	nw.	Do.	15	58	nw.
Do.	9	72	sw.	Indianapolis, Ind.	16	54	s.	Do.	29	52	w.	Providence, R. I.	9	52	s.
Do.	10	50	sw.	Lexington, Ky.	17	68	sw.	North Head, Wash.	1	58	s.	Do.	10	59	nw.
Do.	12	52	sw.	Little Rock, Ark.	8	52	w.	Do.	4	52	s.	Do.	28	55	se.
Do.	18	64	s.	Louisville, Ky.	17	56	sw.	Do.	6	56	nw.	Do.	29	52	nw.
Do.	28	50	nw.	Lynchburg, Va.	27	51	n.	Do.	7	50	se.	St. Louis, Mo.	8	50	ne.
Canton, N. Y.	1	51	w.	Memphis, Tenn.	8	54	nw.	Do.	10	60	s.	Sandy Hook, N. J.	1	58	se.
Cheyenne, Wyo.	1	50	w.	Modena, Utah	13	56	s.	Do.	14	52	s.	Do.	9	55	se.
Do.	14	56	w.	Mount Tamalpais, Calif.	5	56	nw.	Do.	15	58	s.	Do.	19	51	n.
Cleveland, Ohio.	18	56	w.	Do.	12	56	se.	Do.	16	54	s.	Do.	28	74	nw.
Columbus, Ohio.	17	52	w.	Do.	13	52	sw.	Do.	17	72	s.	Do.	29	69	nw.
Detroit, Mich.	1	50	sw.	Do.	15	62	nw.	Do.	30	54	s.	Tatoosh Island, Wash.	10	63	s.
Duluth, Minn.	26	50	w.	New York, N. Y.	1	64	s.	Oklahoma, Okla.	15	50	s.	Do.	15	51	w.
Eastport, Me.	9	51	se.	Do.	5	50	nw.	Oswego, N. Y.	28	50	nw.	Do.	17	62	s.
Do.	28	56	e.	Do.	6	50	nw.	Pensacola, Fla.	8	60	s.	Do.	30	52	s.
Ellendale, N. Dak.	14	52	e.	Do.	9	65	w.	Do.	26	52	sw.	Toledo, Ohio.	1	50	sw.
El Paso, Tex.	15	56	nw.	Do.	10	60	nw.	Point Reyes Light, Calif.	3	61	nw.	Trenton, N. J.	28	62	nw.
Erie, Pa.	8	60	se.	Do.	19	51	n.	Do.	5	62	nw.	Do.	29	54	nw.
Do.	9	67	se.	Do.	21	50	n.	Do.	6	80	nw.	Wichita, Kans.	18	88	nw.
Do.	16	52	se.	Do.	22	54	n.	Do.	7	51	nw.	Williston, N. Dak.	14	52	se.
Do.	18	52	sw.	Do.	27	51	se.								

SPECIAL FORECASTS AND WARNINGS, WEATHER AND CROPS.

WEATHER WARNINGS.

By EDWARD H. BOWIE, Supervising Forecaster, Washington District.

At the beginning of the month a LOW was passing down the St. Lawrence Valley and a trough of relatively low pressure covered the Atlantic States. In the southern end of this trough a secondary center developed and moved eastward, attended by rains along the south Atlantic coast. This low pressure system was followed during the 2d and 3d by high barometer and relatively low temperatures east of the Mississippi River. The evening of the 3d, when an extensive system of low pressure was over the West with a storm center over Lake Superior and another over the southwestern Rocky Mountain Region, warnings of strong winds and snow were sent to open ports on Lake Michigan and cold-wave warnings ordered for Upper Michigan. This low pressure system advanced eastward, the northern storm center passing rapidly down the St. Lawrence Valley and disappearing on the 5th, while the southern storm center moved east-northeastward and reached the Atlantic coast on the 6th. General rains were forecast for the Washington District in advance of these LOWS and much colder weather and high barometer advanced eastward in their wakes. Violent local storms occurred on the 5th in the East Gulf and South Atlantic States, attending the eastward passage of the southern storm center just referred to. On the morning of the 4th cold-wave warnings were ordered for Michigan, except the southeast portion, and for northwestern Indiana, and the evening of the same day the display of cold-wave warnings was extended to cover southeastern Michigan, eastern and southern Indiana, Kentucky, east and central Tennessee, Mississippi and Alabama. On the 5th the display of cold-wave warnings was extended to Georgia, North and South Carolina, and northwestern Florida. Much colder weather covered these regions but the fall in temperature was less than that required to justify cold-wave warnings. At 3 p. m. of the 5th when the center of the disturbance was over the upper Ohio Valley, northwest storm-warnings were displayed on the Atlantic coast at and north of Cape Hatteras and during the night of the 5th strong winds, and in some places gales, occurred in the region where warnings were displayed. The next storm of importance to cover the Washington District was central at 8 a. m. of the 8th over eastern Texas, having moved to that region from Nevada in the preceding 48 hours. This storm moved rapidly northeastward and increased greatly in intensity. At 8 a. m. of the 9th, its center (29.40 inches) was at Toledo, Ohio, and at the same hour on the 10th its center (29.18 inches) was near the mouth of the St. Lawrence River. General and heavy rains and gales attended this cyclone during its passage across the Washington Forecast District. On the morning of the 8th storm warnings were displayed on the Gulf coast at and between Bay St. Louis and Tampa and on the Atlantic coast at and between Titusville, Fla., and Cape Henry. At 4 p. m. of the 8th warnings were ordered for the coast north of Cape Henry to Boston and at 10 p. m. of the same day the region of storm warning display was extended northward to Eastport.

Warnings of northeast gales and snow were sent open ports on Lake Michigan. Gales occurred as forecast and there were heavy snows in parts of lower Michigan. The air pressure increased and remained above normal after the eastward passage of this storm until the 15th. Warnings of the coming of high winds were dispatched to open ports on Lake Michigan on the 12th and 13th and on the latter date northeast storm warnings were displayed on the Atlantic coast at and between Sandy Hook and Eastport. On the morning of the 13th cold-wave warnings were ordered for New England and considerably colder weather followed during the succeeding 24 hours. On the 15th the pressure had become subnormal generally west of the Mississippi River, with storm centers over North Dakota and New Mexico and rains had already set in over the great central valleys. This low pressure system advanced slowly eastward and rains continued over much of the country east of the Mississippi River until the 19th. On the 16th and 17th heavy and general rains and local wind storms occurred in the Ohio and lower Mississippi Valley and the East Gulf States. These conditions had been previously forecast. Warnings of strong winds were sent to open ports on Lake Michigan on the 16th and 17th, and on the 17th at 3 p. m. storm-

warnings were displayed on the Atlantic coast at and between Boston and Cape Henry, and at 6 p. m. of the same day warnings were ordered for the Atlantic coast north of Boston. Strong winds occurred during the following 24 to 36 hours in the region where warnings were displayed. This low pressure system was followed by high barometer and cool weather generally west of the Mississippi River during the 19th to 25th, during which period frequent forecasts of frosts were necessary for the Middle Atlantic and interior of the South Atlantic and East Gulf States; also on the 19th northeast storm warnings were necessary on the Atlantic coast between Boston and Sandy Hook, because of the presence of a storm of considerable intensity near the Bermudas.

The pressure remained low over that region until the 24th, when the storm center passed northeastward to the Grand Banks. Strong winds prevailed off the north Atlantic and middle Atlantic coasts from the 19th to 24th. During the 25th the barometer was low over the Great Plains and the southern Rocky Mountain region and on the 26th this low pressure system was over the Mississippi Valley in the form of a "trough" that extended from Louisiana northward to Lake Superior. This "trough" advanced eastward and on the 27th it covered the interior of the Atlantic States and general rains were then falling over the eastern States. There were strong indications at this time (8 a. m. of the 27th) that the southern end of this trough would become an intense storm in the succeeding 24-hours and, in anticipation of this formation, storm warnings were displayed on the Atlantic coast at and between Jacksonville and Nantucket and on the afternoon of the same day the region of display of storm warnings was extended northward to Eastport. By 8 p. m. of the 27th the center (29.44 inches) of the storm was over New Jersey and at 8 a. m. of the 28th it was near Block Island, R. I., where the barometer stood at 29.14 inches. After remaining approximately stationary for twelve hours the center of the disturbance passed eastward off the coast. Severe gales prevailed along and off the New England and middle Atlantic coasts from the night of the 26th until the end of the month, and heavy snow fell in parts of New England and New York. The warnings of the severe gales were issued well in advance of their occurrence and were no doubt effective in preventing loss of life and of ships. This storm was followed by decidedly colder weather, the display of cold-wave warnings being necessary on the 26th for upper Michigan, on the 27th for the interior of New York and northern New England and on the 28th for parts of southern New England. Moreover, frequent warnings of frosts were necessary for the southern States on and after the 27th of the month.

WARNINGS FROM OTHER DISTRICTS.

Chicago, Ill., forecast district.—Cold-wave warnings were issued for the entire district, except Montana and North Dakota, on the 3d–4th. They were fully verified in northern sections and partially to the southward, but failed of verification in Wyoming, because of the advance of an area of high pressure eastward from the middle Pacific coast.

The only other warnings of importance were those issued for the Dakotas, Minnesota, southern Montana, and extreme northern Wyoming on the 19th. These were mostly verified, except in extreme northern Wyoming.—*Chas. L. Mitchell.*

New Orleans, La., forecast district.—Northwest-storm warnings were issued on indications of the evening map of March 4 and were verified by moderate northwest gales, which attended a moderate HIGH as it moved southward in the rear of a trough of low pressure extending in a northeast-southwest direction.

Small-craft warnings were displayed from Galveston to New Orleans during the afternoon of the 8th, and on the Texas coast during the 25th, and were justified.

On the morning of the 3d a trough of low pressure, with centers over eastern South Dakota and northern Colorado, was advancing southeastward, followed by moderately high pressure from western Canada, with a pronounced temperature gradient. Freezing weather within 36 hours was forecast for the northwestern portion of the district and cold-wave warnings were issued at night for Oklahoma and northwestern Arkansas. The cold-wave warnings were extended on the morning of the 4th to include northern Louisiana and the northern and western portions of east Texas and were further extended in the afternoon over the southeastern portion of east Texas except the extreme west of the coast. Cold-wave warnings were issued on the morning of the 5th for eastern and southern Louisiana. The warnings were verified except in coast sections, where cloudiness generally prevailed on the morning of the 5th and the temperature fall was less than over the interior. Stockmen were given timely notice of the cold wave also.

A cold-wave warning for Oklahoma and the Texas Panhandle issued on the 19th, proved to be not justified. While the area of high pressure in this instance pushed southward along the eastern slope of the Rocky Mountains with a large increase of pressure, the position and movement of the area of low pressure were unfavorable and the temperatures were not unusually low.

Frost warnings were desired only in coast sections at the beginning of the month but were requested for all sections, except the extreme northwest, by the 31st. Warnings of frost, or freezing temperature, or lower, were issued for some portions of the interior on the 5th, 8th, 10th, 11th, 12th, 13th, 17th, 21st, 25th, 26th, 27th, 28th, and 30th, and were verified in most instances.

Fire-weather warnings were issued for the forested regions of Oklahoma on the 13th and 14th, and of Arkansas on the 14th, and were justified.—*R. A. Dyke.*

Denver, Colo., forecast district.—Unsettled weather predominated in the Denver forecast district during March, but temperatures were not severe; in fact, considering the large number of deep low-pressure areas that crossed the central and southern parts of the district, the interruptions to the prevailing mild weather were slight and of short duration. This was unusually true of the northern quadrants of the depressions. In the southern part of the district, especially in New Mexico, there was a remarkable persistency of precipitation during the last decade, with heavy rains and snows on the eastern slope.

On the morning of the 3d a low-pressure area was central in southeastern Colorado while high pressure with zero temperatures prevailed in eastern Montana and Alberta. Cold-wave warnings were issued in the morning for northeastern Colorado, and warnings of a moderate cold wave in the evening for southeastern Colorado. Sharp falls in temperature occurred, but technically the warning was verified only in the eastern border counties. On the morning of the 19th, warnings for the lambing and sheep shearing interests of Utah were issued in anticipation of the coming of colder weather with rain or snow. There was a general fall in temperature, but the precipitation was local. In the evening, warnings of a moderate cold wave in eastern Colorado were issued. Temperature falls of 28° to 32° occurred throughout the eastern half

of the State. On the morning of the 25th low pressure overlay the southern Rocky Mountain region with one of the low centers in southeastern Colorado, while the crest of the anticyclone north of Montana was fully six-tenths of an inch higher. The warning issued was for a moderate cold wave in extreme eastern Colorado. The front of the high-pressure area moved southeastward and sharp falls in temperature occurred, but it is doubtful whether the warning was justified over a considerable area. A frost warning was issued for southeastern New Mexico on the morning of the 26th; this warning was fully verified, several of the substations in the Roswell fruit district reporting a reading of 32°.—*Fredk. H. Brandenburg.*

San Francisco, Cal., forecast district.—During the first and second decades stormy weather continued with but little cessation in the north Pacific States and occurred with marked frequency in northern California and the Plateau region. There was another stormy period in the coast States, from central California north, near the close of the month. In southern California there were two rainy spells; from the 13th to 15th, and from the 19th to 22d. While there were a large number of rainy days in this district, except in southern California, the precipitation for the month was below normal except near the coast from Eureka to Roseburg and at Tatoosh Island.

Storm warnings were ordered on nine days and small-craft warnings on two. Live-stock warnings were issued on the 14th and 15th and on the 19th, for the northern Plateau region and northeastern California. These were only partially verified, as the conditions did not develop the severity expected.

The storm of the 13th and 14th gave the highest winds of the month in California, with hail and thunderstorms at many places in the interior, snow on the mountains around San Francisco Bay and extending well down in the foothills of the Coast Range and Sierra Nevada Mountains. On the 13th, lightning struck the residence of Mrs. Manuel Paulo, in the southwestern portion of Stockton, San Joaquin County, tearing a hole nearly 2 feet in diameter through the roof. Mrs. Paulo, her baby, and a neighbor were in the house at the time but none of them was injured. During the same storm, in Los Angeles County, a small church collapsed at Otterbein and the roof was blown from a farmhouse and power lines were badly damaged in that vicinity.

The temperature was above normal in the northern portion of this district and below in the southern. There were no marked cold spells. Heavy frosts occurred on several mornings in California, but they were not severe enough to cause injury.

At the close of the month deciduous fruit was in full bloom in California and no injury had been reported from either frost, rain, or winds.—*G. H. Willson.*

RIVERS AND FLOODS, MARCH, 1919.

By H. W. SMITH, Temporarily in Charge.

[Dated: Weather Bureau, Washington, Apr. 30, 1919.]

The melting of snow and breaking up of the ice in the Connecticut River on the 21st to 23d caused some ice gorges and the river was about bank-full. Heavy rains on the 26th and 27th caused a second rise to moderate flood stages. But little damage was done.

Moderate to heavy rains in the south Atlantic States from the 7th to 9th caused most of the rivers to rise from 1 to 5 feet above flood stages. Losses were confined mostly to bridges and live stock.

The floods that were in progress in the east Gulf States at the end of February had subsided by the end of the first week of March. Rains were generally heavy from the 5th to 9th, causing most of the rivers to pass flood stages. The greatest rise was in the Alabama River, which was 14 feet above the flood stage at Selma, Ala. A second rise occurred in the Tombigbee and Pearl Rivers from the 19th to 21st. Only the very lowest river bottoms below Tuscaloosa, Ala., were overflowed. The West Pearl River was above flood stage during the entire month.

General rains and melting snow on the 15th and 16th caused moderate flood stages in northwestern Ohio and in southern Michigan. Losses were largely confined to roads, buildings, and suspension of business.

General moderate to heavy rains on the 5th and 6th, 8th and 9th, and 14th to 16th over the Ohio River watershed caused most of the streams to rise slightly above flood stages. The Ohio River was in flood from Henderson, Ky., to the mouth of the river and the Tennessee River passed the flood stages at most places below Guntersville, Ala. As but little plowing had been done and no planting, the losses were confined largely to harvested crops and live stock.

The Miami and Stillwater Rivers were slightly above flood stages on the 17th and 18th, causing a suspension of construction work of the Miami conservancy district. But little damage was done, except that due to suspension of work.

Very heavy rains occurred in Chester and Decatur Counties, Tenn. The following account was furnished by Roscoe Nunn, meteorologist, Nashville, Tenn.:

There was an unusually heavy rainfall over the western part of Tennessee on March 16 and the early morning of the 17th (see figure). The largest amounts recorded were 10.80 inches at Perryville, Decatur County, and 10.58 inches at Henderson, Chester County. Nearly all stations located west of a line extending from Robertson to Hardin

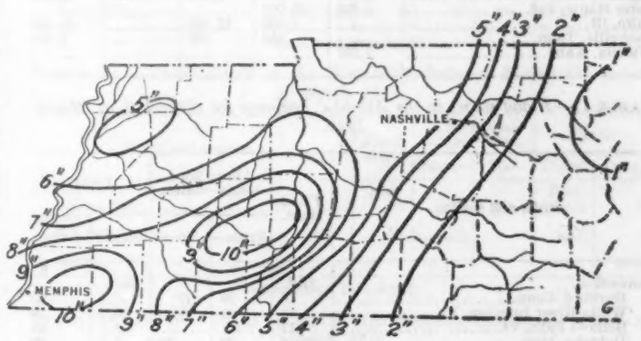

FIG. 1.—Heavy rainfall in West Tennessee on Mar. 16–17, 1919.

Counties received a total of 5 inches or more, while to the east of this line the rainfall was much less. At Memphis 9.72 inches were recorded in 24 hours, exceeding all previous 24-hour records. Of this amount 8.72 inches fell in 12 hours, from 10 a. m. to 10 p. m. of the 16th.

This large amount of water falling within such a short time necessarily resulted in great damage and loss, the money value being probably not less than several hundred thousand dollars. All streams were badly swollen and some of the bottom lands were flooded to an extent not known before. Many bridges were washed away and many others were badly damaged, railroad fills were washed out on several lines, and traffic was seriously interrupted for two or three days. Many persons in low lands were marooned in their homes by the high water, and some were not rescued for two days, being taken from the housetops by boats. Two persons in Madison County were drowned. Much live stock was also lost by drowning, 44 cows being reported by two observers alone. In Memphis there was some complaint of flooding due to inadequate storm sewers, and many cellars were more or less filled with water. There was much additional damage from washing of levees, roadways, and farm lands. Fortunately, very little plowing had been done, and the downpour came on a relatively hard surface; otherwise farm lands would have suffered seriously.

The Illinois River was in flood from the 12th to the end of the month. Much damage was reported, but no estimate of the amount has been received.

High waters in the tributaries caused the Mississippi River to rise slightly above flood stages from Keokuk, Iowa, to Arkansas City, Ark.

The ice broke up in the upper Mississippi and in the Missouri Rivers without forming any serious gorges and no damage was reported.

The western tributaries of the Mississippi reached flood stages at only a few places. Heavy rains on the 16th to 18th caused the Little Arkansas River to rise very rapidly and flood about 1,250 acres of farm land. Several hundred acres of wheat were killed by standing water.

A slight flood occurred in the Trinity River at Dallas, Tex., on the 31st.

The Willamette River at Eugene, Oreg., passed the flood stage on the 3d by 1.5 feet. No damage was done.

Warnings were generally issued well in advance of the flood crests, and much property was saved thereby.

The usual tabular matter and estimated losses by floods and property saved by warnings are shown in the following tables:

Losses by floods, March, 1919.

River district.	Tangible property, bridges, etc.	Crops.	Live stock.	Suspension of business.	Value of warnings.
Charleston, S. C.		$500	$100	$7,500	$20,000
Columbia, S. C.	$2,500	700	1,550	960	95,650
Montgomery, Ala.	3,500	280	1,600	1,500	9,000
Mobile, Ala.		35,000	850	6,600	18,000
Meridian, Miss.	750				500
Grand Rapids, Mich.				20,000	
Lansing, Mich.	100	300			1,000
Saginaw, Mich.	8,000	500	1,000	5,000	10,000
Terre Haute, Ind.	5,000	160,000			
Cairo, Ill.		5,000	12,000		50,000
Nashville, Tenn.		350	100		1,000
Wichita, Kans.	3,590				

TABLE I.—*Flood stages in the Atlantic drainage for the month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Connecticut:	*Feet.*			*Feet.*	
Hartford, Conn.	16	29	(1)	19.8	30
White River Junction, Vt.	13	28	(1)	20.2	28
Bellows Falls, Vt.	12			11.8	29
Holyoke, Mass.	9	29	29	9.2	29
Unadilla:					
New Berlin, N. Y.	8			7.2	10
Chenango:					
Sherburne, N. Y.	8			7.9	10
Roanoke:					
Randolph, Va.	21			19.2	10
Weldon, N. C.	30	11	12	33.0	11

[1] Continued into April.

TABLE I.—*Food stages in the Atlantic drainage for the month of March, 1919*—Continued.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Tar:	*Feet.*			*Feet.*	
Tarboro, N. C.	18			17.0	13
Greenville, N. C.	13	12	15	13.5	13,14
Fishing Creek:					
Enfield, N. C.	14			13.0	5,10
Neuse:					
Neuse, N. C.	14			13.3	5
Smithfield, N. C.	14			13.7	7
Cape Fear:					
Elizabethtown, N. C.	22	8	12	23.7	11
Peedee:					
Cheraw, S. C.	27	10	11	31.2	11
Santee:					
Rimini, S. C.	12	(2)	24	17.8	14
Ferguson, S. C.	12	(2)	30	14.0	15
Catawba:					
Catawba, S. C.	11			10.8	7
		10	10	11.0	10
Wateree:					
Camden, S. C.	24	7	7	24.4	7
		10	11	29.0	10
Congaree:					
Columbia, S. C.	15	10	11	17.0	11
Broad:					
Blairs, S. C.	15	9	10	18.0	10
Saluda:					
Pelzer, S. C.	7			6.6	10
Chappells, S. C.	14	9	12	16.0	10
Edisto:					
Edisto, S. C.	6			5.6	1
Broad:					
Carlton, Ga.	11	9	9	13.0	9
Oconee:					
Dublin, Ga.	22	(2)	1	23.0	1
Ocmulgee:					
Macon, Ga.	18			17.3	11
Hawkinsville, Ga.	29			28.0	1
Abbeville, Ga.	11	(2)	9	16.4	2,3
		12	19	12.7	17
Lumber City, Ga.	15	2	9	18.8	5
				13.3	20,21

[2] Continued from February.

TABLE II.—*Flood stages in the East Gulf drainage for the month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Flint:	*Feet.*			*Feet.*	
Albany, Ga.	20	(1)	7	27.8	3
Bainbridge, Ga.	25	(1)	8	29.5	5
Chattahoochee:					
West Point, Ga.	20	10	10	20.5	10
Eufaula, Ala.	40			35.5	11
Alaga, Ala.	30	(1)	2	39.6	[3] 28
Do.	30	11	13	32.6	12
Alabama:					
Montgomery, Ala.	35	(1)	3	44.8	[3] 28
Do.	35	10	15	47.3	11
Selma, Ala.	25	(1)	5	48.0	1
Do.	35	9	18	49.0	13
Tallapoosa:					
Milstead, Ala.	40	9	10	45.4	9
Coosa:					
Gadsden, Ala.	22	11	11	22.0	11
Lock No. 4, Lincoln, Ala.	17	(1)	1	20.0	[3] 23
Do.	17	9	14	19.2	9
Wetumpka, Ala.	45	10	11	46.5	11
Etowah:					
Canton, Ga.	11	9	9	13.2	9
Cahaba:					
Centerville, Ala.	25			23.5	9
Tombigbee:					
Aberdeen, Miss.	33	12	12	33.5	12
Do.	33	19	21	35.6	20
Demopolis, Ala.	39	(1)	(3)	52.8	21
Black Warrior:					
Tuscaloosa, Ala.	46	9	11	51.2	10
Pascagoula:					
Merrill, Miss.	20			19.7	10
Chickasawha:					
Enterprise, Miss.	21			18.1	10
Shubuta, Miss.	27			24.6	10
Pearl:					
Jackson, Miss.	20	6	(3)	27.6	19
Columbia, Miss.	18	(1)	1	18.3	[3] 28
Do.	18	19	24	19.1	21
West Pearl:					
Pearl River, La.	13	(1)	(3)	15.4	1

[1] Continued from February. [2] February. [3] Continued into April.

TABLE III.—*Flood stages in the Great Lakes drainage for the month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Maumee:	*Feet.*			*Feet.*	
Fort Wayne, Ind.	15	15	22	21.7	18
Napoleon, Ohio	10	17	20	14.0	18
St. Joseph:					
Montpelier, Ohio	10	16	20	12.8	17
Anglaise:					
Defiance, Ohio	10	17	19	13.5	18
Saginaw:					
Saginaw, Mich	19	18	26	23.1	20
Flint:					
Flint, Mich	14	19	19	14.1	19
Fosters, Mich	18	.....	.....	17.9	16
Tittabawassee:					
Midland, Mich	12	17	22	22.0	18
Paines, Mich	20	.....	.....	19.8	17
Pine:					
Alma, Mich	7	16	21	12.1	17
Chippewa:					
Mt. Pleasant, Mich	11	20	20	11.5	20
Cass:					
Vassar, Mich	14	18	19	15.2	18
Grand:					
Lansing, Mich	11	17	19	12.0	17
Grand Ledge, Mich	6	17	17	7.9	17
Ionia, Mich	21	18	20	23.4	18
Lowell, Mich	15	18	22	18.3	19
Grand Rapids, Mich	11	18	24	16.4	20
Red Cedar:					
East Lansing, Mich	8	17	20	10.1	17
Williamston, Mich	10	16	19	10.5	17

TABLE IV.—*Flood stages in the Mississippi drainage (Ohio Basin) during the month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Ohio:	*Feet.*			*Feet.*	
Cloverport, Ky.	40	.....	.....	37.9	19
Henderson, Ky.	33	18	22	35.2	20
Evansville, Ind.	35	18	22	37.5	20
Mount Vernon, Ind.	35	19	23	36.9	21
Shawneetown, Ill.	35	19	29	38.5	22
Paducah, Ky.	43	.....	.....	42.8	22
Cairo, Ill.	45	20	28	48.5	24
Tuscarawas:					
Norris Point, Ohio	8	.....	.....	7.4	10,18
Coshocton, Ohio	8	18	18	9.5	18
Walhonding:					
Walhonding, Ohio	8	16	18	9.5	17,18
Scioto:					
La Rue, Ohio	11	17	18	11.7	18
Prospect, Ohio	10	18	18	10.3	18
Circleville, Ohio	7	16	20	12.4	18
Chillicothe, Ohio	14	18	20	16.3	19
Olentangy:					
Delaware, Ohio	9	.....	.....	8.5	17
Miami:					
Tadmor, Ohio	12	17	18	12.6	18
Hamilton, Ohio	12	17	18	13.7	17
Stillwater:					
West Milton, Ohio	10	16	18	12.5	17
Greene:					
Lock No. 6, Brownsville, Ky.	30	17	19	34.9	18
Lock No. 4, Woodbury, Ky.	33	17	23	44.1	20
Lock No. 2, Rumsey, Ky.	34	17	30	41.3	24
Wabash:					
Bluffton, Ind.	12	16	19	14.0	17
Lafayette, Ind.	11	15	23	23.1	18,19
Terre Haute, Ind.	16	17	26	22.4	20
Vincennes, Ind.	14	18	30	20.4	24,25
Mount Carmel, Ill.	15	17	(1)	24.0	25
White:					
Decker, Ind.	18	19	28	24.4	23
Shoals, Ind.	20	20	24	26.2	23
Anderson, Ind.	12	17	18	14.7	17
Noblesville, Ind.	14	17	18	16.6	17
Indianapolis, Ind.	18	.....	.....	17.2	17
Elliston, Ind.	19	16	23	28.4	19,20
Cumberland:					
Lock A (Fox Bluff), Tenn.	43	.....	.....	40.8	18
Clarksville, Tenn.	46	17	19	50.4	18
Lock D (Dover), Tenn.	49	18	20	51.4	19
French Broad:					
Penrose, N. C.	13	9	9	13.2	9
Asheville, N. C.	4	9	9	4.0	9
Tennessee:					
Guntersville, Ala.	31	.....	.....	28.8	10
Florence, Ala.	18	9	11	19.5	9
Riverton, Ala.	32	8	14	39.6	10
Do.	32	18	19	34.7	18
Savannah, Tenn.	40	.....	.....	36.3	19
Johnsonville, Tenn.	31	.....	.....	30.7	12
Do.	31	17	21	35.3	19

(1) Continued into April.

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TABLE V.—*Flood stages in Mississippi drainage during month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Mississippi:	*Feet.*			*Feet.*	
St. Paul, Minn.	14	.....	.....	12.5	25-26
Keokuk, Iowa	14	19	25	14.8	20
Warsaw, Ill.	17	19	21	17.8	20
Quincy, Ill.	14	19	27	16.0	21
Hannibal, Mo.	13	18	(1)	16.3	21
Louisiana, Mo.	12	19	29	14.2	22
Grafton, Ill.	18	24	29	18.5	25-27
Alton, Ill.	21	24	25	21.1	25
Cape Girardeau, Mo.	30	.....	.....	28.1	25
New Madrid, Mo.	34	21	(1)	38.1	25
Memphis, Tenn.	35	25	(1)	37.4	29
Helena, Ark.	42	25	(1)	46.0	30-31
Arkansas City, Ark.	42	24	(1)	47.9	31
Greenville, Miss.	42	.....	.....	39.8	31
Vicksburg, Miss.	45	.....	.....	42.9	31
St. Croix:					
Stillwater, Minn.	11	25	(1)	13.5	31
Des Moines:					
Ottumwa, Iowa	10	16	20	13.2	18
Illinois:					
Morris, Ill.	13	16	24	20.3	18
Peru, Ill.	14	13	(1)	23.1	18
Henry, Ill.	7	4	(1)	16.7	29
Peoria, Ill.	16	17	(1)	23.2	22
Havana, Ill.	14	18	(1)	18.6	27-22
Beardstown, Ill.	12	16	(1)	19.5	29-30
Pearl, Ill.	12	21	(1)	16.6	29-30
Missouri:					
St. Charles, Mo.	25	.....	.....	23.2	20
Grand:					
Chillicothe, Mo.	18	17	23	29.0	19
Brunswick, Mo.	10	18	24	12.8	21-22
Meramec:					
Pacific, Mo.	11	.....	.....	10.3	19
Bourbeuse:					
Union, Mo.	10	19	19	10.6	19
St. Francis:					
Marked Tree, Ark.	17	30	(1)	17.0	30-31
Yazoo:					
Greenwood, Miss.	36	.....	.....	34.4	31
Yazoo City, Miss.	25	.....	.....	22.5	31
Tallahatchie:					
Swan Lake, Miss.	25	21	29	29.8	26-27
Ouachita:					
Camden, Ark.	30	20	23	32.0	21
Atchafalaya:					
Melville, La.	37	.....	.....	34.0	31
James:					
Huron, S. Dak.	9	15	(1)	13.4	25-26
Missouri:					
Kansas City, Mo.	22	.....	.....	20.8	18
Kansas:					
Wamego, Kans.	16	16	16	17.8	16
Topeka, Kans.	21	.....	.....	20.0	17
Smoky Hill:					
Lindsborg, Kans.	19	.....	.....	17.8	15
Neosho:					
Neosho Rapids, Kans.	22	17	18	25.0	18
Le Roy, Kans.	24	.....	.....	23.4	20
Iola, Kans.	10	.....	.....	9.6	21
Oswego, Kans.	17	.....	.....	15.3	23
Cottonwood:					
Emporia, Kans.	19	17	19	21.2	18
Little Arkansas:					
Sedgwick, Kans.	18	16	18	23.6	16
Petit Jean:					
Danville, Ark.	20	.....	.....	17.8	18
White:					
Georgetown, Ark.	22	.....	.....	20.3	26-27
Black:					
Black Rock, Ark.	14	17	21	16.2	18
Cache:					
Jelks, Ark.	9	17	(1)	10.0	28-30

(1) Continued into April.

TABLE VI.—*Flood stages in the West Gulf drainage during the month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Trinity:	*Feet.*			*Feet.*	
Dallas, Tex.	25	31	(1)	29.9	31
Sabine:					
Bon Wier, Tex.	20	.....	.....	19.7	30
Gila:					
Kelvin, Ariz.	5	.....	.....	4.2	24-25

(1) Continued into April.

TABLE VII.—*Flood stages in the Pacific drainage during the month of March, 1919.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Eel:	*Feet.*			*Feet.*	
Fernbridge, Calif.	15	.....	.....	14.3	3
Willamette:					
Eugene, Oreg.	10	3	3	11.5	3
Oregon City, Oreg.	12	.....	.....	11.4	4-5

CORRIGENDUM FOR JANUARY, 1919, TABLES.

January REVIEW, page 51, Table IV, line beginning "Melville, La.," should be stricken out.

MEAN LAKE LEVELS DURING MARCH, 1919.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Apr. 3, 1919.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during March, 1919:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.89	580.74	572.47	246.01
Above or below—				
Mean stage of February, 1919	−0.19	+0.08	+0.27	+0.10
Mean stage of March, 1918	+0.37	−0.34	+0.22	−0.60
Average stage for March, last 10 years	+0.31	+0.81	+0.79	+0.37
Highest recorded March stage	−0.39	−2.21	−1.38	−1.80
Lowest recorded March stage	+1.23	+1.63	+1.64	+1.71
Average relation of the March level to—				
February level		+0.1	+0.2	+0.2
April level		−0.3	−0.6	−0.7

*Lake St. Clair's level: In March, 575.39 feet.

EFFECT OF WEATHER ON CROPS, MARCH.

By J. WARREN SMITH, Agricultural Meteorologist.

Farm work.—Outdoor activities were delayed in the South and in some central districts by frequent and, in places, heavy rains, especially during the first part of the month, but conditions were more favorable during the latter part. Little field work was begun in March in the extreme northern districts, where the ground was still frozen at the close of the month. Vegetation in general advanced well during March in central and eastern districts, but it was too cool in the extreme upper Great Plains and in the far Southwest, and the season was backward in those districts at the close of the month.

Winter grains.—The month was almost universally favorable for the growth of winter grains and at the close, wheat, rye, barley, and winter oats were nearly everywhere reported in good to excellent condition. The weather conditions were designated as ideal for winter wheat in Kansas and the plants were stooling well in Oklahoma.

Spring crops.—The frequent rains and wet soil caused considerable delay in planting cotton and early corn in the South, and growth was rather slow in some of the more southern districts on account of cool nights, while the ground was too wet for plowing corn land to best advantage in portions of the Ohio and upper Mississippi Valleys. As a result of frequent rains the work of preparing the ground and seeding cotton was from 1 to 2 weeks behind the average season in much of the cotton belt. The seeding of the earlier spring grains was under way at the close of the month as far north as the lower Ohio and Missouri Valleys.

Truck crops.—Cool weather and wet soil caused considerable delay in planting truck crops the first part of the month, but conditions were more favorable the latter part and much of this work was done in the southern half of the country. Truck was greatly damaged in southern Florida by heavy rains about the middle of the month.

Live stock.—March was favorable for meadows, pastures, and ranges in nearly all sections and grass was starting well, although in some central Rocky Mountain districts ranges were short. Ranges in western Texas improved with ample rainfall and stock was generally in good condition in that region.

Fruit.—March was generally favorable for fruit and only a small amount of winter killing was reported, although some damage was done to peaches in northern Missouri, southern Iowa, and at places in Colorado. At the close of the month early fruits were blooming as far north as Virginia and Oklahoma.

CLIMATOLOGICAL TABLES.*

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, March, 1919.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	56.7	+0.5	Ozark	83	16	Florence	21	1†	7.23	+1.84	Bermuda	11.86	Eufaula	3.43
Arizona	49.3	−2.8	2 stations	93	31	Flagstaff	−1	1	0.80	−0.17	Henrys Camp	3.44	5 stations	0.00
Arkansas	53.2	+0.6	Pine Bluff	86	22	Dodd City	11	1	5.47	+1.05	Brinkley	11.66	Umphers	0.98
California	49.0	−2.8	Indio	94	31	Madeline	−13	10	3.47	−1.27	Crescent City	12.24	2 stations	0.01
Colorado	33.2	−1.0	Lamar	82	19	3 stations	−26	10†	1.51	+0.17	Cascade	6.31	Hoyt	0.02
Florida	66.9	+1.2	Moore Haven	90	6†	Orange City	34	29	5.41	+2.20	Fort Lauderdale	12.21	Key West	0.25
Georgia	58.5	+1.9	Bainbridge	84	16	Ramhurst	26	12	4.22	−0.56	Quitman	7.66	Millen	1.80
Hawaii (February)	68.9	+0.5	Mahukona	91	7	2 stations	45	10	2.87	−3.75	Honomanu	17.28	5 stations	0.00
Idaho	32.9	−0.4	Glenns Ferry	90	31†	Irwin	−18	7	1.86	+0.22	Tripod Mountain	4.95	Challis	0.14
Illinois	42.7	+3.0	2 stations	77	20†	Aurora	− 9	6	3.44	+0.43	2 stations	7.01	Warsaw	1.25
Indiana	42.7	+2.6	2 stations	80	20†	Hammond	5	6	4.90	+1.12	Cambridge City	6.90	Hammond	1.84
Iowa	37.5	+4.2	Thurman	78	19	Inwood	−11	1	2.33	+0.56	Lacona	5.40	Spencer	0.81
Kansas	44.1	+1.3	Lakin	84	19	2 stations	2	1	1.91	+0.52	Chapman	7.15	Hays	0.33
Kentucky	47.6	+1.6	Beattyville	81	25	7 stations	16	1	5.65	+0.99	Bowling Green	9.61	Berea	2.43
Louisiana	61.4	0.0	3 stations	88	13†	Robeline	23	1	4.59	−0.24	Stables	10.07	Cades	1.48
Maryland-Delaware	45.8	+3.7	Delaware City, Del.	78	17	Grantsville, Md	14	6	3.99	+0.22	Princess Anne, Md.	5.35	Grantsville, Md.	1.79
Michigan	32.1	+3.3	St. Joseph	70	16	Humboldt	−30	6	2.67	+0.57	Allegan	6.15	Whitefish Point	0.20
Minnesota	26.3	+1.2	4 stations	70	29†	Roseau	−37	5	1.07	−0.07	Stillwater	2.39	Fosston	0.29
Mississippi	57.1	+1.1	Yazoo City	86	15	4 stations	22	1	6.94	+1.24	Merrill	13.60	Woodville	2.84
Missouri	46.3	+2.9	Poplar Bluff	90	21	2 stations	− 2	1	2.40	−0.69	Caruthersville	8.67	Amoret	0.37
Montana	28.5	−1.6	Bigtimber	74	30	Browning	−34	1	0.67	−0.28	Heron	3.75	3 stations	0.00
Nebraska	37.8	+2.4	Hartington	84	29	Kirkwood	−13	4	0.88	−0.23	Auburn	3.75	North Loup	T.
Nevada	39.2	−1.1	Las Vegas	88	29	Metropolis	−10	10	0.82	−0.12	Marlette Lake	3.92	Jungo	0.12
New England	35.5	+4.9	2 stations	70	26	Van Buren, Me.	−26	7	4.65	+0.90	Colchester, Conn	7.78	Cornwall, Vt	1.65
New Jersey	43.2	+5.2	2 stations	77	17†	Newton	12	14	5.32	+1.27	Peterson	7.40	Bridgeton	3.77
New Mexico	40.8	−3.2	Artesia	87	19	Elizabethtown	−10	9	2.56	+1.64	Harveys U. Ranch	6.97	Cloverdale	0.20
New York	35.0	+3.4	Fayetteville	75	25	3 stations	−15	7†	3.76	+0.67	Mount Hope	8.20	Little Falls	1.24
North Carolina	51.4	+1.4	Wenona	82	17	Banners Elk	19	12	4.02	−0.69	Highlands	10.53	Rockingham	1.73
North Dakota	17.3	−5.3	Marmarth	67	28	Willow City	−38	2	0.82	−0.01	Hettinger	2.63	Taylor	0.08
Ohio	41.0	+2.2	3 stations	79	25†	Hillhouse	10	7	4.04	+0.46	West Manchester	8.19	Brilliant	2.10
Oklahoma	51.2	−0.8	Frederick	94	10	3 stations	11	1	1.91	+0.04	Kenton	3.98	Bristow	0.50
Oregon	42.4	−0.8	Pendleton	80	29	Lakeview	− 7	7	3.68	−0.36	Deadwood	15.78	Rio Hermoso	0.00
Pennsylvania	41.1	+3.6	George School	79	17	West Bingham	6	6	3.57	−0.81	Ephrata	6.99	Altoona	1.29
Porto Rico	74.7	+0.8	Comerio Falls	97	1	Cayey	49	18	2.06	−1.40	Corozal	7.32	2 stations	0.00
South Carolina	56.5	+1.7	Oaks	82	18	Saluda	27	29	2.86	−0.96	Walhalla	6.99	Meriwether	1.10
South Dakota	29.6	−0.5	2 stations	76	18†	Pollock	−33	5	0.85	−0.14	Armour	2.50	Roslyn	0.08
Tennessee	50.4	+0.9	Carthage	80	25	Crossville	11	1	7.39	+2.40	Henderson	15.46	Johnson City	2.22
Texas	57.3	−1.5	Barstow	92	14	2 stations	15	1†	2.85	+0.69	Angleton	9.21	Riogrande	0.00
Utah	37.4	−1.3	St. George	82	31	East Portal	−23	.....	0.83	−0.69	Silver Lake	2.91	2 stations	0.00
Virginia	47.8	+2.5	Hopewell	80	17	Burkes Garden	16	12	3.64	−0.21	Mineral	5.13	Winchester	1.77
Washington	41.8	+0.3	3 stations	78	29†	Conconully	− 1	1	3.14	+0.20	Forks	17.94	Wenatchee	0.05
West Virginia	44.5	+1.7	Cuba	81	25	Bayard	12	23	2.92	−0.85	Green Sulphur Springs.	4.81	Parsons	1.60
Wisconsin	31.2	+2.3	Delavan	66	20	Winter	−28	6	1.59	−0.04	Waukesha	4.09	Solon Springs	0.20
Wyoming	32.3	+1.8	Upton	78	31	Sheridan Creek	−26	7	0.53	−0.57	2 stations	1.72	Painter	0.00

* For explanation of the following tables and charts, see this REVIEW, January, 1919, pp. 52–53.

† Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, March, 1919.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
New England.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F. 37.2	°F. +4.5	°F		°F	°F.		°F	°F.	°F.	°F.			% 76	*In.* 4.16	*In.* +0.4		*Miles*									0–10 6.5	*In.*	*In.*
Eastport	76	67	85	28.99	30.08	+.15	34.0	+5.1	56	26	40	6	14	28	33	31	26	75	2.67	−1.6	16	10,394	nw.	56	e.	28	9	5	17	6.6	1.6	T.
Greenville	1,070	6	.....	28.89	30.10	.....	28.7	.....	60	26	38	− 9	15	19	43	.....	.....	.....	4.03	.....	12	.....	sc.	.....	.....	.....	.....	.....	.....	.....	.....	18.0	T.
Portland, Me.	103	82	117	29.98	30.10	+.14	36.4	+4.4	60	21	43	10	14	30	31	32	27	72	4.02	+0.3	15	8,500	n.	38	e.	28	8	8	15	6.1	5.0	0.7
Concord	288	70	79	29.77	30.06	+.06	36.7	+5.2	65	26	46	10	14	28	36	.....	.....	.....	3.28	−0.2	10	4,551	nw.	35	w.	10	13	8	10	4.5	0.3	0.0
Burlington	404	11	48	29.70	30.16	+.16	31.2	+3.9	62	27	40	− 2	7	23	40	.....	.....	.....	3.32	+1.5	15	9,333	n.	37	w.	10	7	9	15	6.5	23.5	13.0
Northfield	876	12	60	29.16	30.15	+.15	30.0	+3.8	59	26	40	− 1	15	20	40	26	22	79	5.42	+2.6	13	7,005	n.	30	nw.	13	6	11	14	6.9	15.7	7.2
Boston	125	115	188	29.94	30.08	+.11	40.8	+5.8	63	5	48	15	14	33	32	36	30	69	4.11	0.0	12	9,168	nw.	40	w.	10	5	9	17	7.5	2.4	0.0
Nantucket	12	14	90	30.05	30.06	+.08	38.6	+1.8	57	26	44	24	29	34	22	37	35	89	3.81	−0.2	18	15,335	ne.	48	ne.	22	5	3	23	7.8	4.9	0.0
Block Island	26	11	46	30.03	30.06	+.08	39.6	+3.7	54	26	45	21	28	34	28	38	36	91	4.16	−0.2	11	17,072	ne.	70	nw.	28	10	1	20	6.8	0.8	0.0
Providence	160	215	251	29.90	30.08	+.10	40.1	+4.4	60	5	48	15	14	32	32	36	31	74	4.31	−0.3	12	12,187	nw.	59	nw.	10	7	8	16	6.4	1.0	T.
Hartford	159	122	140	29.92	30.10	+.11	40.4	+5.4	67	21	49	15	14	32	37	34	28	67	6.10	+1.8	11	7,109	n.	36	se.	27	7	5	19	6.7	3.4	T.
New Haven	106	117	155	29.98	30.10	+.11	41.2	+5.8	68	21	50	19	14	33	31	35	29	68	4.55	+0.1	10	10,414	n.	48	n.	28	9	6	16	6.0	2.7	0.0
Middle Atlantic States.							44.1	+4.1											3.82	+0.2	69										5.5		
Albany	97	102	115	30.02	30.14	+.13	36.9	+4.8	65	26	46	13	14	28	35	32	28	73	4.86	+2.1	11	7,822	n.	33	n.	21	12	7	12	5.5	9.3	6.0
Binghamton	871	10	69	29.18	30.13	+.11	36.7	+4.7	72	26	46	13	7	27	40	.....	.....	.....	3.22	+0.6	10	5,919	nw.	36	nw.	28	7	7	17	6.8	6.2	2.5
New York	314	414	454	29.75	30.10	+.10	42.0	+4.5	65	21	50	22	28	34	26	36	29	63	4.69	+0.6	12	17,958	nw.	92	nw.	28	6	9	16	6.7	1.9	0.0
Harrisburg	374	94	104	29.74	30.15	+.12	43.0	+5.2	69	17	52	23	31	34	31	36	28	60	3.28	+0.2	11	7,666	n.	36	nw.	29	13	9	9	4.7	1.2	0.2
Philadelphia	117	123	190	30.00	30.13	+.11	45.4	+5.4	73	17	54	24	31	37	32	40	36	73	4.81	+1.4	12	10,282	n.	47	nw.	29	11	9	11	5.4	3.0	0.0
Reading	325	81	98	29.78	30.14	.....	43.6	.....	69	26	53	23	14	34	30	37	31	65	4.72	+1.2	9	8,136	n.	44	nw.	29	11	8	12	5.3	0.6	0.0
Scranton	805	111	119	29.26	30.15	+.13	39.1	+4.2	76	26	49	18	7	29	40	36	33	82	3.02	−0.1	8	7,021	nw.	39	sw.	9	8	10	13	6.3	5.0	T.
Atlantic City	52	37	48	30.05	30.11	+.09	43.4	+4.6	62	13	50	26	31	37	22	39	35	77	3.82	+0.1	13	7,965	nw.	38	nw.	28	11	8	12	5.6	0.1	0.0
Cape May	18	13	49	.....	30.13	+.12	44.1	+3.3	62	21	50	29	31	38	22	.....	.....	.....	3.99	+0.3	12	.....	nw.	.....	.....	.....	11	9	11	.....	0.1	0.0
Sandy Hook	22	10	57	30.08	30.10	.....	42.1	.....	57	5	48	23	14	36	23	38	35	81	3.94	.....	13	16,863	nw.	74	nw.	28	8	9	14	5.9	1.8	0.0
Trenton	190	159	183	29.90	30.11	.....	43.0	.....	72	17	52	22	31	34	32	37	31	68	4.64	+0.6	13	12,095	n.	62	nw.	28	10	7	14	6.0	6.5	0.0
Baltimore	123	100	113	30.00	30.14	+.11	46.2	+4.3	75	17	55	29	14	38	31	39	32	62	4.22	+0.3	10	6,842	nw.	32	nw.	29	14	8	9	4.7	T.	0.0
Washington	112	62	85	30.02	30.14	+.10	46.4	+4.2	76	17	56	29	31	37	32	39	32	62	4.02	+0.2	10	8,926	nw.	46	nw.	28	13	5	13	5.3	T.	0.0
Lynchburg	681	153	188	29.39	30.14	+.09	49.4	+4.0	73	26	60	31	15	39	34	41	34	62	3.02	−0.8	10	7,507	n.	51	n.	27	12	14	5	4.9	0.0	0.0
Norfolk	91	170	205	30.04	30.14	+.11	50.4	+2.7	75	17	59	33	29	42	30	44	39	73	3.36	−0.9	11	12,786	ne.	56	nw.	28	9	12	10	5.3	0.0	0.0
Richmond	144	11	52	29.97	30.13	+.09	49.5	+2.6	75	17	60	29	12	39	31	42	35	66	3.51	−0.2	13	7,587	nw.	45	nw.	27	10	9	12	5.6	0.0	0.0
Wytheville	2,293	49	55	27.73	30.15	+.10	44.5	+2.2	70	25	55	25	31	34	36	37	31	67	1.95	−2.5	9	5,904	nw.	40	sw.	9	14	6	11	4.5	T.	0.0
South Atlantic States.							53.9	+2.0											2.78	−1.3	73										5.1		
Asheville	2,255	70	84	27.77	30.16	+.10	47.5	+2.6	71	24	58	27	12	37	39	40	34	68	4.23	−0.8	8	8,824	nw.	50	e.	8	17	5	9	4.2	T.	T.
Charlotte	773	153	161	29.29	30.14	+.09	52.0	+1.2	73	25	62	34	28	42	28	46	41	72	2.70	−1.9	9	5,169	n.	26	nw.	27	8	15	8	5.4	0.0	0.0
Hatteras	11	12	50	30.10	30.11	+.07	52.6	+1.2	71	17	59	37	29	46	25	49	46	82	2.94	−2.5	14	13,416	n.	51	nw.	27	8	9	14	5.8	0.0	0.0
Raleigh	376	103	110	29.73	30.14	+.09	52.3	+1.9	75	17	63	35	28	42	33	47	43	77	2.38	−1.9	11	6,301	ne.	36	n.	27	9	6	16	5.7	0.0	0.0
Wilmington	78	81	91	30.04	30.13	+.08	55.6	+1.9	75	9	65	38	29	46	28	49	44	72	2.20	−1.4	10	6,458	n.	34	sw.	5	9	11	11	5.6	0.0	0.0
Charleston	48	11	92	30.07	30.12	+.06	59.5	+2.3	76	31	67	43	28	52	27	53	48	74	4.05	+0.3	11	8,740	n.	35	ne.	15	14	3	14	4.9	0.0	0.0
Columbia, S. C.	351	41	57	29.76	30.14	+.08	56.8	+2.8	76	16	67	37	29	46	32	49	43	67	1.11	−2.6	7	5,977	n.	36	sw.	27	12	7	12	5.0	0.0	0.0
Augusta	180	62	77	29.93	30.12	+.06	58.1	+2.2	77	17	69	38	29	48	34	52	48	74	1.90	−3.0	8	5,227	nw.	29	sw.	5	12	6	13	5.0	0.0	0.0
Savannah	65	150	194	30.05	30.12	+.06	60.6	+2.3	75	17	68	44	29	53	26	54	49	72	3.07	−0.6	10	9,065	e.	46	w.	27	14	4	13	5.0	0.0	0.0
Jacksonville	43	200	245	30.06	30.11	+.05	63.8	+1.9	81	5	71	46	29	57	22	57	53	76	3.24	−0.3	8	9,990	ne.	43	se.	17	12	9	10	4.9	0.0	0.0
Greenville, S. C.	1,013	113	122	29.02	30.12	.....	53.6	.....	74	21	63	34	28	44	30	46	39	65	3.58	.....	10	7,146	n.	35	w.	17	14	8	9	4.6	0.0	0.0
Florida Peninsula.							71.8	+ 1.5											4.99	+ 2.7	74										4.3		
Key West	22	10	64	30.04	30.06	+ .01	75.0	+ 2.2	84	9	80	63	31	70	13	67	64	74	0.25	− 1.2	3	8,756	se.	31	nw.	27	20	6	5	3.1	0.0	0.0
Miami	25	71	79	30.06	30.09	.....	71.7	− 0.3	82	9	77	51	21	66	26	65	62	75	9.74	+ 7.0	8	7,607	e.	33	ne.	12	12	10	9	5.3	0.0	0.0
Tampa	35	79	92	30.06	30.10	+ .03	68.8	+ 2.5	82	8	78	49	29	60	24	61	57	74	4.97	+ 2.2	11	5,964	ne.	27	ne.	12	13	9	9	4.6	0.0	0.0
East Gulf States.							58.8	+ 1.6											5.26	− 0.6	68										4.6		
Atlanta	1,174	190	216	28.89	30.14	+ .08	54.0	+ 1.6	74	25	64	32	1	44	30	46	39	65	3.58	− 2.2	8	9,748	nw.	46	nw.	27	16	4	11	4.5	0.0	0.0
Macon	370	78	87	29.73	30.13	+ .07	57.9	+ 3.1	78	16	69	36	29	47	37	50	43	65	3.21	− 2.3	7	5,478	nw.	31	s.	8	14	5	12	4.3	0.0	0.0
Thomasville	273	49	58	29.81	30.11	+ .05	63.0	+ 2.8	80	16	72	41	29	54	31	54	49	68	7.36	+ 2.3	8	3,690	n.	24	sw.	9	12	7	12	4.8	0.0	0.0
Pensacola	56	149	185	30.05	30.11	+ .05	61.4	+ 0.3	80	22	68	44	1	54	25	56	53	78	2.96	− 2.4	6	11,191	se.	60	s.	8	12	9	10	4.7	0.0	0.0
Anniston	741	9	57	29.35	30.15	+ .09	54.1	+ 1.6	76	24	66	30	1	42	37	.....	.....	.....	5.97	+ 0.2	8	5,190	nw.	42	e.	8	17	2	12	4.3	0.0	0.0
Birmingham	700	11	48	29.38	30.15	+ .09	55.5	+ 0.3	77	24	66	28	1	44	36	46	39	61	5.91	+ 0.2	7	6,066	n.	38	se.	8	17	2	12	4.2	0.0	0.0
Mobile	57	125	161	30.04	30.10	+ .04	61.6	+ 2.5	80	22	71	44	1	53	29	54	48	68	5.09	− 2.1	6	8,582	n.	35	se.	17	12	7	12	5.2	0.0	0.0
Montgomery	223	100	112	29.88	30.13	+ .07	59.4	+ 1.5	78	24	70	37	1	49	30	51	45	65	10.31	+ 3.9	4	5,567	n.	24	sw.	5	12	11	8	4.6	0.0	0.0
Corinth	469	6	.....	.....	.....	.....	53.2	.....	77	24	65	28	1	42	41	.....	.....	.....	.....	.....	9	.....	n.	.....	.....	.....	11	13	7	.....	.....	.....
Jackson	304	5	.....	.....	.....	.....	58.2	.....	79	15	70	29	1	46	39	.....	.....	.....	5.15	.....	6	.....	ne.	.....	.....	.....	16	9	6	.....	.....	.....
Meridian	375	85	93	29.72	30.13	+ .08	56.8	+ 0.5	77	16	68	30	1	46	35	49	43	66	5.31	− 0.3	6	4,486	ne.	28	se.	8	14	6	11	4.4	0.0	0.0
Vicksburg	247	65	74	29.84	30.13	+ .09	59.5	+ 1.3	80	16	70	30	1	49	31	52	47	71	4.95	− 1.3	6	5,835	se.	42	w.	5	15	5	11	4.6	0.0	0.0
New Orleans	51	76	84	30.04	30.10	+ .05	64.0	+ 2.0	81	16	72	47	1	56	24	57	52	71	3.22	− 2.1	5	5,253	se.	26	nw.	17	14	9	8	4.5	0.0	0.0
West Gulf States.							57.8	− 0.1											2.76	− 0.4	73										5.1		
Shreveport	249	77	93	29.84	30.12	+ .10	58.2	0.0	79	24	68	28	1	48	31	50	43	65	3.14	− 1.4	6	5,637	se.	40	s.	15	17	4	10	4.4	0.0	0.0
Bentonville	1,303	11	44	28.72	30.11	+ .10	49.8	+ 2.5	75	20	61	15	1	38	39	.....	.....	.....	2.71	− 1.1	6	4,818	s.	28	sw.	16	13	10	8	4.5	4.1	0.0
Fort Smith	457	79	94	29.61	30.10	+ .09	54.2	+ 2.9	76	30	65	23	1	44	35	47	40	66	1.25	− 2.4	4	5,155	e.	58	sw.	16	11	8	12	5.5	0.0	0.0
Little Rock	357	139	147	29.75	30.14	+ .11	53.8	+ 1.1	74	15	63	24	1	45	31	47	41	68	6.44	+ 1.5	7	6,620	e.	52	w.	8	15	8	8	4.6	T.	0.0
Brownsville	57	4	26	.....	.....	.....	69.2	.....	87	31	79	46	6	60	30	.....	.....	.....	0.44	.....	4	.....	se.	.....	.....	.....	.....	.....	.....	.....	.....	0.0	0.0
Corpus Christi	20	69	77	30.03	30.05	+ .07	64.5	+ 0.1	82	17	70	45	1	59	23	60	58	83	1.18	− 0.7	7	9,608	se.	38	se.	15	9	14	8	5.5	0.0	0.0
Dallas	512	109	117	29.52	30.07	.....	56.6	.....	76	4	67	28	1	46	44	.....	.....	.....	2.97	.....	7	7,376	se.	46	se.	15	12	7	12	4.8	0.0	0.0
Fort Worth	670	106	114	29.33	30.05	+ .07	56.1	− 0.5	77	4	67	27	1	46	45	50	44	71	3.34	+ 1.6	7	7,642	s.	42	s.	15	11	7	13	5.4	0.0	0.0
Galveston	54	106	114	30.04	30.10	+ .09	60.7	− 1.6	76	17	66	39	6	56	26	57	54	83	2.20	− 0.7	6	8,734	se.	39	nw.	25	10	10	11	5.2	0.0	0.0
Houston	138	111	121	29.93	30.08	.....	61.9	− 1.6	81	22	71	35	6	53	32	.....	.....	.....	3.25	.....	8	6,933	se.	45	se.	25	13	7	11	4.7	0.0	0.0
Palestine	510	64	72	29.55	30.09	+ .09	57.8	− 0.7	80	22	68	29	5	48	30	52	48	77	3.83	+ 0.4	7	5,897	ne.	33	s.	14	12	6	13	5.6	0.0	0.0
Port Arthur	34	58	66	30.04	30.08	.....	61.1	.....	78	22	69	38	6	54	28	55	52	79	2.31	.....	8	7,541	se.	37	nw.	5	13	8	10	4.9	0.0	0.0
San Antonio	701	119	132	29.32	30.05	+ .07	61.0	− 1.1	83	16	70	36	1	52	30	54	48	70	1.39	− 0.3	9	6,985	se.	42	nw.	8	10	11	10	5.3	0.0	0.0
Taylor	582	55	63	29.47	30.09	+ .10	57.6	− 2.1	77	21	68	30	1	47	38	.....	.....	.....	2.09	− 0.5	9	6,754	se.	36	n.	4	11	7	13	5.5	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, March, 1919*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.							Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.				%	*In.*	*In.*		*Miles*									*0–10.*	*In.*	*In.*
							46.2	**+ 2.3**													**68**	**5.46**	**+ 1.0**									**5.2**		
Chattanooga	762	189	213	29.35	30.17	+ .11	52.5	+ 1.2	75	25	62	27	1	43	30	44	35	58	7.33	+ 1.1	8	7,295	ne.	36	nw.	31	15	7	9	4.4	0.0	0.0
Knoxville	996	102	111	29.08	30.15	+ .09	51.0	+ 2.8	76	15	62	28	1	40	34	44	37	65	4.85	− 0.7	8	5,147	n.	28	s.	16	14	7	10	4.6	T.	0.0
Memphis	399	76	97	29.75	30.18	+ .14	53.6	+ 1.5	74	4	62	23	1	45	28	46	40	66	12.41	+ 6.6	9	6,332	n.	54	nw.	8	17	4	10	4.2	0.7	0.0
Nashville	546	168	191	29.59	30.19	+ .14	50.4	+ 1.2	76	25	60	22	1	40	31	42	35	63	8.67	+ 3.2	9	7,984	ne.	46	se.	16	14	8	9	4.3	T.	0.0
Lexington	989	193	230	29.09	30.19	+ .14	45.6	+ 2.2	73	25	55	19	1	36	29	.....	.....	.....	3.71	− 1.0	11	10,686	ne.	68	sw.	17	13	4	14	5.5	T.	0.0
Louisville	525	219	255	29.61	30.20	+ .15	47.8	+ 2.5	75	25	57	19	1	38	32	40	34	66	5.72	+ 1.4	9	9,621	ne.	56	sw.	17	13	9	9	4.7	T.	0.0
Evansville	431	139	175	29.71	30.19	+ .15	47.7	+ 3.1	76	25	57	18	1	39	31	42	36	69	5.05	+ 0.4	9	8,913	ne.	58	sw.	17	10	11	10	5.0	0.0	0.0
Indianapolis	822	194	230	29.27	30.18	+ .14	42.6	+ 3.0	72	25	52	14	1	34	29	38	33	72	6.72	+ 2.7	12	9,862	s.	54	s.	16	10	11	10	5.3	2.9	0.0
Terre Haute	575	96	129	29.54	30.17	.....	44.2	.....	70	25	54	14	1	35	34	39	35	76	3.90	.....	9	8,351	s.	42	se.	16	6	17	8	5.6	1.6	0.0
Cincinnati	628	11	51	29.50	30.20	+ .15	43.7	+ 2.9	73	25	54	18	1	34	34	37	32	70	5.27	+ 1.6	11	6,683	ne.	42	sw.	17	11	6	14	5.5	T.	0.0
Columbus	824	173	222	29.29	30.19	+ .15	41.8	+ 2.6	71	25	51	19	1	32	32	36	31	71	4.58	+ 1.4	13	9,662	nw.	51	w.	17	9	8	14	5.8	0.2	0.0
Dayton	899	181	216	29.18	30.16	.....	42.8	+ 2.5	71	25	52	17	1	33	31	37	32	70	5.16	+ 1.7	13	8,660	ne.	46	w.	17	13	7	11	5.2	0.1	0.0
Pittsburgh	842	353	410	29.25	30.18	+ .14	42.2	+ 2.7	72	17	52	19	6	32	36	36	30	66	1.89	− 1.1	10	10,139	nw.	48	sw.	18	11	4	16	6.2	1.5	0.0
Elkins	1,940	41	50	28.07	30.19	+ .14	40.9	+ 1.8	72	26	52	20	23	29	45	35	30	73	2.76	− 1.3	12	5,193	nw.	35	w.	1	10	5	16	6.4	2.2	0.1
Parkersburg	638	77	84	29.53	30.20	+ .15	44.6	+ 2.3	76	16	55	23	6	34	39	38	32	68	2.37	− 1.4	11	5,289	nw.	31	sw.	17	13	5	13	5.6	0.4	0.0
Lower Lake Region.							**35.8**	**+2.9**													**72**	**3.08**	**+0.4**									**5.8**		
Buffalo	767	247	280	29.32	30.17	+0.15	35.5	+4.3	70	26	44	12	7	28	40	31	26	74	2.47	−0.2	10	14,416	sw.	76	sw.	1	10	3	18	6.2	1.0	0.1
Canton	448	10	61	29.65	30.15	.....	29.8	+2.1	62	26	39	− 2	6	21	35	.....	.....	.....	3.97	+1.1	15	8,437	n.	51	w.	1	12	6	13	5.4	14.6	6.0
Oswego	335	76	91	29.78	30.16	+ .15	33.5	+2.1	67	26	41	7	7	26	37	30	26	76	2.94	+0.1	12	10,825	ne.	50	nw.	28	7	6	18	6.9	7.5	3.0
Rochester	523	97	113	29.60	30.19	+ .17	35.6	+4.3	74	26	44	13	7	27	32	30	23	65	2.66	−0.3	13	7,985	nw.	39	w.	9	7	9	15	6.3	3.3	0.8
Syracuse	597	97	113	29.50	30.16	+ .14	34.8	+3.4	69	26	44	7	7	26	35	.....	.....	.....	4.30	+1.9	11	9,903	nw.	48	nw.	29	4	13	14	6.5	17.6	4.0
Erie	714	130	166	29.38	30.17	+ .15	37.3	+4.2	69	17	45	18	7	30	32	32	27	70	1.63	−1.0	9	12,443	ne.	67	se.	9	10	11	10	5.5	2.1	0.0
Cleveland	762	190	201	29.34	30.19	+ .16	37.1	+2.9	67	26	44	18	1	31	32	34	29	75	2.67	−0.1	11	10,947	ne.	55	w.	18	14	3	14	5.4	1.2	0.0
Sandusky	629	62	103	29.48	30.18	+ .15	37.6	+2.4	67	26	44	17	1	31	32	.....	.....	.....	3.37	+0.8	11	11,133	ne.	48	n.	31	9	8	14	5.9	4.2	T.
Toledo	628	208	243	29.50	30.20	+ .17	37.4	+2.6	65	16	45	17	1	30	31	33	28	71	3.55	+1.3	11	11,318	n.	50	sw.	1	13	6	12	5.1	9.0	T.
Fort Wayne	856	113	124	29.25	30.20	.....	38.6	−0.3	69	25	48	12	1	30	35	34	29	73	5.34	.....	12	7,704	ne.	40	sw.	17	11	10	10	5.3	6.4	0.0
Detroit	730	218	245	29.38	30.20	+ .17	36.3	+3.4	64	16	44	16	6	28	27	32	28	75	3.22	+0.8	10	9,428	n.	50	sw.	1	12	9	10	5.3	8.0	0.0
Upper Lake Region.							**31.3**	**+3.3**													**77**	**2.61**	**+0.3**									**5.7**		
Alpena	609	13	92	29.53	30.22	+ .19	29.6	+4.6	75	26	36	11	13	23	28	26	22	76	2.65	+0.6	9	10,677	nw.	42	w.	1	9	11	11	6.0	7.3	0.0
Escanaba	612	54	60	29.53	30.22	+ .18	28.0	+4.5	50	16	35	− 3	6	21	28	25	23	85	1.79	−0.2	5	7,680	s.	32	ne.	13	15	8	8	4.0	5.3	1.0
Grand Haven	632	54	92	29.49	30.20	+ .17	33.9	+3.1	64	25	42	5	7	26	27	31	27	78	5.28	+2.8	12	10,182	n.	48	s.	16	11	9	11	5.5	11.6	0.0
Grand Rapids	707	70	87	29.41	30.21	+ .18	35.4	+2.4	68	16	44	10	7	27	29	31	26	73	4.93	+2.4	11	5,557	nw.	26	nw.	27	9	11	11	5.4	18.2	0.0
Houghton	684	62	99	29.41	30.17	+ .13	28.7	+2.9	59	19	34	− 2	7	19	38	.....	.....	.....	1.42	−0.7	14	7,530	e.	41	w.	20	4	12	15	6.9	7.0	T.
Lansing	878	11	62	29.22	30.19	.....	33.8	+2.5	66	16	43	9	6	24	31	30	26	78	3.48	+1.2	11	5,838	sw.	24	sw.	17	9	8	14	6.1	22.2	T.
Ludington	637	60	66	29.48	30.20	.....	33.0	.....	59	16	40	13	7	26	26	30	26	80	2.92	.....	10	9,075	n.	44	s.	16	11	9	11	5.7	3.8	0.0
Marquette	734	77	111	29.40	30.23	+ .18	28.6	+4.9	56	19	36	1	6	21	30	25	22	78	0.92	−1.2	10	8,900	nw.	38	s.	3	5	9	17	7.1	13.9	3.4
Port Huron	638	70	120	29.47	30.18	+ .15	34.1	+4.5	62	26	41	12	6	27	27	31	27	80	1.96	−0.5	9	10,425	ne.	44	ne.	31	7	13	11	5.7	8.9	0.0
Saginaw	641	48	82	29.48	30.19	.....	33.5	.....	65	16	42	11	6	25	30	30	26	77	3.05	+0.4	10	8,737	ne.	37	sw.	1	8	12	11	5.7	11.6	0.0
Sault Sainte Marie	614	11	61	29.51	30.23	+ .20	27.4	+6.1	51	20	36	− 2	13	19	27	23	19	74	0.94	−0.9	6	8,387	nw.	36	nw.	27	12	7	12	5.1	2.8	T.
Chicago	823	140	310	29.28	30.20	+ .17	38.5	+4.1	68	20	45	8	1	32	28	35	30	69	4.32	+1.8	13	10,107	ne.	44	s.	16	10	8	13	5.7	11.0	0.0
Green Bay	617	109	144	29.51	30.19	+ .15	32.4	+5.6	58	19	40	1	1	25	30	28	24	74	1.26	−1.1	8	9,198	s.	36	ne.	13	8	9	14	6.5	1.8	0.0
Milwaukee	681	119	133	29.43	30.19	+ .16	35.0	+4.1	65	16	42	4	1	28	25	31	28	78	3.38	+0.7	9	8,779	ne.	39	se.	14	12	6	13	5.6	10.2	0.0
Duluth	1,133	11	47	28.92	30.19	+ .13	23.9	−0.2	55	19	31	−14	2	16	26	21	18	83	1.16	−0.4	10	9,799	ne.	50	w.	26	9	11	11	5.7	1.6	T.
North Dakota.							**18.2**	**−2.6**													**86**	**1.12**	**+0.2**									**5.6**		
Moorhead	940	8	57	29.13	30.20	+ .12	23.1	+1.7	54	24	32	−19	5	14	32	21	19	88	0.74	−0.4	10	7,010	se.	40	e.	14	12	12	7	4.5	2.4	0.0
Bismarck	1,674	8	57	28.32	30.19	+ .13	19.1	−3.0	50	31	28	−25	5	10	34	18	16	88	1.17	+0.1	7	7,035	e.	36	se.	21	8	9	14	6.1	7.4	T.
Devils Lake	1,482	11	44	28.50	30.16	+ .11	14.4	−4.1	40	31	24	−21	2	5	33	14	12	91	1.49	+0.5	5	7,855	w.	38	n.	14	7	12	12	6.3	0.3	0.0
Ellendale	1,457	10	56	28.53	30.15	.....	21.2	.....	52	28	30	−22	5	13	28	20	18	88	0.71	.....	5	10,522	se.	52	e.	14	7	12	12	6.3	0.3	0.0
Grand Forks	835	12	89	.....	.....	.....	19.0	.....	43	31	28	−20	2	10	31	18	.....	.....	0.71	.....	7	.....	nw.	40	s.	15	13	9	9	.....	1.2	T.
Williston	1,872	41	48	28.05	30.13	+ .09	16.4	−5.2	52	31	26	−26	5	6	35	15	11	78	1.08	+0.4	7	5,812	se.	52	se.	14	8	14	9	5.8	7.0	T.
Upper Mississippi Valley.							**39.6**	**+3.6**													**74**	**2.70**	**+0.3**									**5.6**		
Minneapolis	918	10	208	29.12	30.13	.....	30.4	.....	63	19	39	− 8	2	22	37	.....	.....	.....	0.84	−0.8	6	9,421	se.	39	s.	19	4	15	12	6.4	1.5	0.0
St. Paul	837	201	236	29.25	30.19	+ .14	30.6	+2.4	61	19	39	− 9	2	22	33	.....	.....	.....	0.81	−0.8	7	9,256	se.	49	se.	14	6	14	11	5.9	2.1	0.0
La Crosse	714	11	48	29.39	30.19	+ .15	33.7	+2.8	64	19	44	− 5	1	24	37	.....	.....	.....	2.36	+0.7	7	4,406	nw.	19	w.	17	7	7	17	6.7	T.	0.0
Madison	974	70	78	29.12	30.21	+ .17	33.2	+3.1	60	19	42	− 5	1	24	31	30	25	74	2.17	0.0	8	7,884	se.	38	n.	30	6	4	21	7.4	3.7	0.0
Wausau	1,247	4	.....	28.80	30.18	.....	29.4	.....	60	19	39	−10	6	20	34	.....	.....	.....	1.06	.....	5	.....	se.	.....	.....	.....	14	8	9	4.6	1.4	0.0
Charles City	1,015	10	49	29.07	30.18	+ .13	34.2	+5.8	69	29	44	− 6	1	24	31	30	27	80	2.48	+0.6	8	5,843	s.	25	ne.	20	8	14	9	5.7	0.2	0.0
Davenport	606	71	79	29.50	30.18	+ .15	40.0	+4.6	69	29	50	1	1	30	28	35	31	75	3.98	+1.8	8	6,140	e.	30	e.	14	8	13	10	5.6	T.	0.0
Des Moines	861	84	97	29.23	30.16	+ .12	39.0	+3.3	68	29	49	1	1	29	29	35	31	77	3.67	+2.0	8	6,136	e.	34	sw.	11	9	12	10	5.6	3.3	0.0
Dubuque	698	81	96	29.43	30.20	+ .16	36.6	+3.4	66	29	46	− 4	1	27	32	32	27	73	2.24	0.0	7	5,306	s.	28	nw.	17	11	9	11	5.5	3.0	0.0
Keokuk	614	64	78	29.48	30.18	+ .15	43.0	+5.1	71	29	52	8	1	34	29	37	32	71	1.49	−0.9	6	6,194	nw.	39	se.	16	14	10	7	4.6	0.2	0.0
Cairo	358	87	93	29.76	30.16	+ .12	49.2	+2.2	72	4	57	20	1	41	35	43	37	67	6.61	+2.6	9	7,912	ne.	46	ne.	8	10	8	13	5.6	0.0	0.0
Peoria	609	11	45	29.50	30.18	+ .15	40.8	+3.8	70	20	50	6	1	31	27	36	33	79	4.52	+1.6	12	6,279	s.	29	s.	16	13	9	9	5.2	4.4	0.0
Springfield, Ill.	644	10	91	29.46	30.15	+ .12	42.9	+3.8	71	20	52	10	1	33	29	38	34	77	2.26	−0.8	10	7,041	s.	34	s.	16	9	8	14	5.9	4.5	0.0
Hannibal	534	74	109	29.57	30.16	+ .14	44.4	+2.8	73	20	54	10	1	34	33	.....	.....	.....	2.58	−0.2	8	7,159	nw.	50	sw.	16	12	6	13	5.5	1.3	0.0
St. Louis	567	265	303	29.53	30.15	+ .12	47.1	+3.6	73	29	56	16	1	38	43	41	35	67	1.72	−1.7	9	10,341	s.	50	ne.	8	14	10	7	4.0	1.2	0.0
Missouri Valley.							**39.8**	**+3.7**													**74**	**1.60**	**−0.3**									**5.4**		
Columbia, Mo.	781	11	84	29.30	30.16	+0.13	46.6	+5.2	73	20	58	12	1	36	35	.....	.....	.....	1.30	−1.7	8	6,201	se.	29	w.	17	11	9	11	5.4	T.	0.0
Kansas City	963	161	181	29.08	30.13	+ .11	45.3	+4.5	70	15	55	9	1	36	36	39	33	67	1.54	−1.3	6	9,178	n.	40	nw.	15	11	14	6	4.8	T.	0.0
St. Joseph	967	11	49	29.07	30.13	.....	43.4	.....	70	29	53	8	1	34	32	38	32	69	6.00	.....	9	6,832	se.	37	nw.	15	11	14	6	4.6	0.3	0.0
Springfield, Mo.	1,324	98	104	28.71	30.13	+ .11	48.4	+4.9	73	20	59	14	1	38	41	41	34	67	2.23	−1.8	7	8,505	se.	38	se.	15	17	10	4	3.4	11.6	0.0
Iola	984	11	50	29.05	30.11	+ .10	47.8	+5.4	70	20	59	10	1	36	39	.....	.....	.....	1.06	−1.3	10	6,351	s.	29	s.	15	8	14	9	5.7	0.2	0.0
Topeka	983	85	101	.....	.....	.....	44.2	+3.3	70	19	54	7	1	34	34	.....	.....	.....	5.73	+3.4	9	8,427	n.	36	s.	19	9	12	10	5.5	0.6	0.0
Drexel	1,296	10	54	28.68	30.10	.....	38.4	.....	72	29	49	1	1	28	37	34	31	81	0.98	.....	6	9,011	se.	44	sw.	19	9	10	12	5.7	2.1	0.0
Lincoln	1,189	11	84	28.83	30.13	+ .11	40.8	+4.8	73	29	51	6	1	31	36	35	29	69	1.00	−0.3	8	8,326	s.	33	s.	19	5	14	12	6.1	0.9	0.0
Omaha	1,105	115	122	28.93	30.14	+ .10	40.5	+4.5	74	29	50	2	1	30	38	35	31	72	1.59	+0.2	4	6,799	s.	33	nw.	3	10	12	9	5.3	1.3	0.0
Valentine	2,598	47	54	27.30	30.09	+ .06	34.6	+2.7	73	28	46	− 3	1	23	43	30	26	77	0.51	−0.7	6	7,620	n.	36	e.	14	9	11	11	5.5	1.4	0.0
Sioux City	1,135	94	164	28.90	30.15	+ .10	36.3	+3.7	73	29	46	− 2	1	27	32	32	28	78	1.14	−0.1	5	9,300	se.	45	se.	14	10	8	13	5.7	2.7	0.0
Huron	1,306	59	74	28.71	30.16	+ .10	29.6	+2.9	64	18	39	−11	5	20	36	26	23	81	0.75	−0.2	6	8,702	se.	41	se.	14	12	9	10	5.0	2.7	0.0
Pierre	1,572	70	75	28.41	30.14	+ .09	29.4	−0.1	70	29	39	− 7	2	20	36	25	21	76	1.30	0.0	6	7,349	e.	37	nw.	3	10	6	15	5.7	3.0	0.0
Yankton	1,233	49	57	28.77	30.13	+ .08	34.0	+2.8	74	29	44	− 4	1	24	38	.....	.....	.....	1.09	0.0	8	6,268	se.	32	nw.	3	7	10	14	6.7	5.5	0.0

TABLE I.—*Climatological data for Weather Bureau stations, March, 1919*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departures from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.							Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity.									
																										Miles per hour.	Direction.	Date.							
Northern Slope.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F*		*°F*	*°F.*		*°F*	*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*									*0–10*	*In.*	*In.*
							30.9	**+0.1**													**68**	**0.68**	**−0.4**									**5.6**		
Billings	3,140	5					31.9		73	28	47	−9	1	17	51						68	0.43		5		ne.				13	12	6		6.8	0.0
Havre	2,505	11	44	27.36	30.12	+.12	17.4	−9.9	59	31	28	−26	1	7	44	16	14	88				0.74	+0.3	10	4,942	e.	30	sw.	17	9	15	7	5.3	7.7	0.0
Helena	4,110	87	114	25.72	30.02	+.01	30.4	−0.6	67	30	41	−15	1	20	36	25	17	62				0.70	0.0	10	4,923	sw.	27	sw.	17	5	11	15	6.5	13.4	0.0
Kalispell	2,962	11	34	26.85	29.96	−.03	32.8	−0.2	63	29	43	−4	1	23	34	29	23	69				0.45	−0.6	5	3,627	nw.	26	sw.	30	8	10	13	6.0	5.5	0.0
Miles City	2,371	26	48	27.48	30.13	+.11	27.7	−0.9	60	30	39	−11	1	16	38	24	21	81				0.57	−0.2	5	4,601	n.	24	n.	3	9	16	6	5.2	5.4	0.0
Rapid City	3,250	50	58	26.58	30.10	+.09	33.4	+1.8	71	29	46	−5	1	21	58	27	19	62				0.66	−0.4	7	6,856	se.	44	n.	3	6	15	10	6.3	6.4	0.0
Cheyenne	6,088	84	101	23.92	30.00	+.04	33.7	+0.7	65	18	44	7	7	23	37	28	21	66				1.52	+0.6	11	9,681	w.	56	w.	14	8	14	9	5.5	13.8	T.
Lander	5,372	60	68	24.55	29.97	−.02	37.2	+5.9	67	30	50	9	4	24	38	29	18	49				0.13	−1.5	3	4,088	w.	48	w.	16	9	13	9	5.5	1.4	0.0
Sheridan	3,790	10	47	26.05	30.04		33.0		71	30	48	−8	1	18	58	26	18	63				0.43		7	4,184	nw.	34	nw.	3	17	6	8	4.1	4.6	0.0
Yellowstone Park	6,200	11	48	23.78	30.03	+.01	29.2	+2.7	59	29	40	−6	7	19	34	24	18	67				1.00	−1.2	15	6,276	s.	40	sw.	2	8	12	11	5.7	9.8	T.
North Platte	2,821	11	51	27.12	30.12	+.12	37.0	+1.7	76	29	48	4	2	26	43	32	27	76				0.44	−0.4	5	5,046	se.	28	n.	25	9	9	13	5.9	0.5	0.0
Middle Slope.							**44.3**	**+1.8**													**68**	**1.36**	**−0.1**									**5.8**		
Denver	5,292	106	113	24.66	29.97	+.02	40.8	+2.1	72	18	51	17	10	30	39	33	24	56				0.66	−0.3	10	5,792	s.	36	w.	14	8	12	11	5.8	3.4	0.0
Pueblo	4,685	80	86	25.25	29.98	+.06	41.6	+1.0	73	18	54	21	10	29	47	34	24	58				1.43	+0.6	9	5,091	nw.	39	w.	14	11	7	13	5.6	7.0	0.0
Concordia	1,392	50	58	28.62	30.13	+.12	42.0	+1.3	72	14	52	11	5	32	37	30	32	74				0.90	−0.6	6	6,888	s.	36	sw.	19	5	11	15	6.8	2.8	0.0
Dodge City	2,509	11	51	27.40	30.05	+.08	43.8	+2.1	77	19	54	14	4	33	36	38	33	74				0.94	+0.1	7	8,498	ne.	38	sw.	14	11	8	12	5.5	2.6	0.0
Wichita	1,358	139	158	28.64	30.09	+.10	46.6	+2.5	73	14	56	15	5	37	29	41	36	74				2.37	+0.1	7	10,898	s.	38	nw.	15	12	8	11	5.3	3.2	0.0
Altus	1,410	5					51.4		83	14	64	21	5	39	49							2.80		6		se.				14	3	14		3.8	0.0
Muskogee	652	4					52.2		75	3	63	22	1	41	35							2.30		6		se.				16	7	8		0.0	0.0
Oklahoma	1,214	10	47	28.79	30.09	+.11	51.0	+1.8	78	14	62	19	5	40	35	44	38	69				1.88	−0.5	7	11,210	s.	50	s.	15	10	8	13	5.6	2.5	0.0
Southern Slope.							**52.7**	**−0.5**													**59**	**2.77**	**+1.8**									**4.6**		
Abilene	1,738	10	52	28.22	30.04	+.08	54.0	−0.9	81	14	64	25	5	44	36	46	38	63				2.73	+1.4	8	9,031	se.	49	w.	15	11	7	13	5.5	0.0	0.0
Amarillo	3,676	10	49	26.27	30.03	+.08	46.4	+1.4	77	13	59	19	5	34	38	38	31	66				1.73	+1.1	5	9,788	s.	40	sw.	14	14	13	4	4.5	1.7	0.0
Del Rio	944	64	71	29.03	30.02	+.07	61.1	−0.6	81	15	71	39	1	51	36							1.42	+0.2	5	9,108	se.	39	nw.	8	9	17	5	4.6	0.0	0.0
Roswell	3,566	75	85	26.34	29.96	+.06	49.3	−2.0	80	19	63	22	11	36	47	39	26	48				5.19	+4.7	7	7,543	s.	44	w.	15	18	9	4	3.6	T.	0.0
Southern Plateau.							**48.0**	**−3.0**													**49**	**0.87**	**+0.4**									**3.3**		
El Paso	3,762	110	133	26.14	29.90	+.02	54.6	−1.3	79	18	67	28	5	42	39	42	26	40				0.62	+0.2	6	9,830	nw.	56	nw.	15	24	5	2	2.5	0.0	0.0
Santa Fe	7,013	57	66	23.18	29.97	+.08	37.6	−1.8	62	19	47	16	6	28	30	31	25	66				1.70	+1.0	10	6,454	se.	38	se.	20	8	13	10	5.3	3.9	0.0
Flagstaff	6,908	8	57	23.26	29.92	+.01	31.7	−4.2	60	31	44	−1	1	20	39	27						1.38		10		w.	40	sw.	13	18	10	3		8.4	T.
Phoenix	1,108	76	81	28.79	29.95	+.04	57.5	−3.0	86	31	71	34	1	44	37	46	34	49				0.97	+0.5	5	4,156	e.	30	w.	13	18	9	4	3.3	0.0	0.0
Yuma	141	9	54	29.82	29.97	+.03	61.2	−3.3	91	31	75	38	5	47	40	48	35	47				0.41	+0.1	3	4,033	n.	37	nw.	13	25	4	2	1.7	0.0	0.0
Independence	3,910	11	42	25.95	30.02	+.08	45.3	−4.3	73	31	58	23	8	32	37	35	22	45				0.66	+0.2	3	5,696	nw.	34	se.	13	15	11	5	3.9	2.0	0.0
Needles	488	4																																	
Middle Plateau.							**49.4**	**−0.5**													**59**	**0.79**	**−0.5**									**5.1**		
Reno	4,532	74	81	25.43	30.01	+.03	41.0	0.0	67	31	53	17	10	29	39	33	25	58				0.84	−0.4	6	5,736	w.	45	sw.	2	12	12	7	4.6	3.3	0.0
Tonopah	6,090	12	20	23.99	29.98		36.6		60	30	45	16	9	28	28	30	20	56				1.05	−0.3	5	7,748	se.	41	nw.	5	14	10	7	3.8	8.0	0.0
Winnemucca	4,344	18	56	25.58	30.02	+.01	39.2	−0.4	68	29	51	14	9	28	39	33	27	67				0.57	−0.4	6	5,974	sw.	45	sw.	2	8	9	14	6.2	3.2	0.0
Modena	5,479	10	43	24.55	29.96	.00	36.8	−2.4	64	30	49	10	15	25	36	30	21	58				0.85	−0.4	9	7,707	w.	56	s.	13	12	14	5	4.7	7.5	0.0
Salt Lake City	4,360	163	203	25.58	29.98	.00	42.6	+1.2	68	30	51	22	10	34	26	36	29	60				0.54	−1.5	9	6,269	se.	44	se.	20	11	7	13	5.5	1.4	0.0
Grand Junction	4,602	82	96	25.34	29.94	.00	42.6	−0.9	70	20	54	14	6	31	33	34	24	53				0.87	+0.2	9	4,428	se.	40	sw.	13	9	11	11	5.7	3.9	0.0
Northern Plateau.							**42.1**	**+1.8**													**64**	**1.36**	**−0.2**									**6.4**		
Baker	3,471	48	53	26.40	30.02	−.01	38.1	+2.6	64	27	48	16	7	28	34	33	27	67				0.73	−0.7	10	4,999	se.	22	s.	1	9	7	15	5.8	2.5	0.0
Boise	2,739	78	86	27.15	30.03	.00	42.8	+0.6	68	29	52	22	9	33	33	37	28	59				1.82	+0.4	11	4,492	se.	25	se.	13	9	7	15	6.2	5.2	0.0
Lewiston	757	40	48	29.18	30.01	−.02	46.4	+2.4	74	29	57	28	25	36	38							1.36	+0.1	13	2,541	e.	20	s.	10	8	4	19	6.6	T.	0.0
Pocatello	4,477	60	68	25.42	29.99	−.02	38.3	+1.4	63	29	46	19	9	30	29	33	26	66				0.99	−0.8	10	7,467	se.	42	sw.	5	5	8	18	6.7	8.2	0.0
Spokane	1,929	101	110	27.92	30.00	−.01	40.2	+1.3	68	29	48	19	6	32	30	35	30	69				1.36	−0.2	12	5,021	sw.	30	sw.	16	7	6	18	6.8	4.6	0.0
Walla Walla	991	57	65	28.93	30.01	−.01	46.8	+2.8	76	29	55	34	7	39	34	40	32	60				1.91	0.0	13	4,295	s.	25	sw.	16	8	10	13	6.2	T.	0.0
North Pacific Coast Region.							**45.7**	**+0.8**													**80**	**4.41**	**−0.3**									**6.8**		
North Head	211	11	56	29.80	30.04	+.03	45.0	+0.1	66	29	49	36	12	41	19	44	42	90				4.90	−0.4	19	14,350	s.	72	s.	17	3	11	17	7.2	0.0	0.0
North Yakima	1,071	4					53.1		75	29	59	24	3	32	44							0.10		4		nw.				17	12	2		T.	0.0
Port Angeles	29	8	53	30.01	30.04		42.6		61	29	50	30	9	36	22							1.27	−0.9	14	4,323	s.	26	nw.	14	8	13	10	5.7	0.0	0.0
Seattle	125	215	250	29.90	30.04	+.05	44.7	+0.5	70	29	51	34	1	39	28	41	37	79				1.84	−1.8	17	8,218	s.	40	s.	1	2	9	20	8.0	0.0	0.0
Tacoma	213	113	120	29.80	30.03	+.03	44.9	+0.7	73	29	52	32	20	38	33	42	39	82				3.51	−0.5	16	4,956	sw.	31	sw.	4	2	15	14	7.0	T.	0.0
Tatoosh Island	86	7	57	29.88	29.98	+.02	43.8	+0.9	56	29	48	34	1	40	14	42	40	85				10.19	+1.6	22	12,652	s.	63	s.	10	6	10	15	6.8	T.	0.0
Medford	1,425	4					46.3		73	26	58	24	10	34	41							1.76		12		nw.				9	6	16		T.	0.0
Portland, Oreg.	153	68	106	29.88	30.04	+.02	48.2	+1.9	73	29	56	33	25	41	31	44	39	74				4.64	−0.5	20	5,304	sw.	24	sw.	15	6	9	16	6.5	0.0	0.0
Roseburg	510	9	57	29.52	30.08	+.04	47.4	+0.8	71	31	56	30	10	38	37	42	37	73				4.50	+0.5	17	2,616	s.	20	w.	2	3	20	8	6.1	0.0	0.0
Middle Pacific Coast Region.							**49.3**	**−2.0**													**77**	**3.41**	**−0.8**									**5.3**		
Eureka	62	73	89	30.05	30.12	+.06	47.6	−0.4	68	29	53	34	9	42	22	45	44	87				6.25	−0.7	15	5,689	se.	37	n.	19	6	8	17	6.7	0.0	0.0
Mount Tamalpais	2,375	11	18	27.57	30.08	+.02	42.9	−4.2	60	31	48	31	14	37	18	40	36	81				3.64	−1.5	15	13,522	nw.	62	nw.	15	12	7	12	4.9	1.1	0.0
Point Reyes Light	490	7	18	29.53	30.05		48.0	−1.6	58	21	52	37	14	45	11							1.97		14	15,998	nw.	80	nw.	6	11	5	15	5.8	0.0	0.0
Red Bluff	332	50	56	29.70	30.06	+.02	51.8	−2.0	90	31	61	33	10	43	35	46	39	67				3.44	−0.3	9	4,911	s.	32	se.	12	16	5	10	4.7	0.0	0.0
Sacramento	69	106	117	30.01	30.08	+.05	51.2	−3.0	76	31	59	34	10	43	28	47	42	74				1.50	−1.5	8	6,301	se.	42	se.	13	12	11	8	4.5	0.0	0.0
San Francisco	155	209	213	29.92	30.09	+.03	52.6	−0.1	67	20	59	40	14	46	20	47	43	74				2.74	−0.4	9	5,694	sw.	37	sw.	13	11	9	11	5.2	0.0	0.0
San Jose	141	12	110	29.95	30.10		51.0	−2.7	71	31	60	32	9	42	33							2.87	−0.1	10	4,800	nw.	34	s.	12	10	8	13	5.6	0.0	0.0
South Pacific Coast Region.							**53.9**	**−1.6**													**71**	**2.11**	**−0.5**									**4.7**		
Fresno	327	89	98	29.73	30.09	+.08	52.7	−2.2	74	31	63	36	1	43	28	47	41	69				1.07	−0.7	7	5,071	nw.	30	nw.	5	12	10	9	4.9	0.0	0.0
Los Angeles	338	159	191	29.68	30.05	+.03	55.6	−1.3	78	17	64	40	15	47	28	48	42	68				2.18	−0.8	7	5,116	ne.	26	nw.	5	16	5	10	4.5	0.0	0.0
San Diego	87	62	70	29.96	30.05	+.03	55.0	−1.2	71	8	62	40	15	48	26	50	46	74				1.83	+0.1	6	4,829	nw.	39	s.	13	15	8	8	4.3	0.0	0.0
San Luis Obispo	201	32	40	29.88	30.10	+.04	52.2	−1.6	78	31	61	33	15	43	31	46	41	72				3.35	−0.6	9	3,360	nw.	22	nw.	8	13	4	14	4.9	T.	0.0
West Indies.																																			
San Juan, P. R.	82	8	54	29.94	30.03	+.01	75.0		86	20	80	64	20	70	22							2.33	−0.8	16	10,879	ne.	40	ne.	17	13	14	4	4.5	0.0	0.0
Panama Canal.																																			
Balboa Heights	118	7	97	29.75	29.87	.00	80.8	−0.5	92	16	89	67	20	73	23	72	70	73				T.	−0.6	0	10,196	n.	36	nw.	7	16	15	0	4.1	0.0	0.0
Colon	36	30	97	29.86	29.90	+.01	79.6	−0.4	84	30	82	73	28	77	10	74	72	79				0.61	−1.0	13	11,828	n.	28	ne.	18	5	15	11	6.3	0.0	0.0
Alaska.																																			
Juneau	80	11	19				28.2		50	30	33	7	16	24	20	25	17	67				4.43		15	4,532	ne.	25	e.	31	7	9	15	6.6	11.7	0.0

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during March, 1919, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	24			1.21																	
Albany, N. Y.	27			0.93														0.54			
Alpena, Mich.	17			0.99														0.39			
Amarillo, Tex.	22–23			0.83														*			
Anniston, Ala.	8			2.25														*			
Asheville, N. C.	27	8:03 a. m.	12:30 p. m.	1.14	8:39 a. m.	8:56 a. m.	0.02	0.14	0.30	0.45	0.51							0.50			
Atlanta, Ga.	5			0.72																	
Atlantic City, N. J.	1			0.88														0.50			
Augusta, Ga.	5			0.78														0.61			
Baker, Oreg.	1			0.18														0.62			
Baltimore, Md.	27			1.60														*			
Bentonville, Ark.	16			0.72														0.61			
Binghamton, N. Y.	1			0.46														0.47			
Birmingham, Ala.	8			1.98														0.36			
Bismarck, N. Dak.	14–15			0.65														0.65			
Block Island, R. I.	1			0.65														*			
Boise, Idaho.	2			0.62														0.31			
Boston, Mass.	9			0.89														*			
Buffalo, N. Y.	9			1.03														0.30			
Burlington, Vt.	28			1.57														*			
Cairo, Ill.	16			3.97														0.19			
Canton, N. Y.	9–10			1.06														0.50			
Charles City, Iowa.	14–15			1.83														*			
Charleston, S. C.	8–9	12:15 p. m.	D. N. A. M.	1.93	1:55 a. m.	2:24 a. m.	0.93	0.11	0.33	0.56	0.73	0.82	0.86					*			
Charlotte, N. C.	8–9			1.18																	
Chattanooga, Tenn.	4–5	10:30 p. m.	1:53 p. m.	2.09	5:54 a. m.	7:10 a. m.	0.31	0.17	0.29	0.37	0.48	0.50	0.55	0.58	0.63	0.68	0.76	0.37			
Cheyenne, Wyo.	24–25			0.70														0.83	1.02		
Chicago, Ill.	15			1.09														*			
Cincinnati, Ohio.	26			1.38														0.32			
Cleveland, Ohio.	16			0.81														0.28			
Columbia, Mo.	16			0.26														0.20			
Columbia, S. C.	5			0.60														0.21			
Columbus, Ohio.	15			1.69														0.44			
Concord, N. H.	28			1.17														0.49			
Concordia, Kans.	15			0.18														*			
Corpus Christi, Tex.	25			0.63														0.09			
Dallas, Tex.	24			1.08														0.49			
Davenport, Iowa.	15–16			3.01														0.33			
Dayton, Ohio.	26			1.05														*			
Del Rio, Tex.	22–23	11:30 p. m.	5:00 a. m.	1.18	12:24 a. m.	12:44 a. m.	0.07	0.07	0.21	0.36	0.68							0.35			
Denver, Colo.	22–23			0.21																	
Des Moines, Iowa.	15			2.44														*			
Detroit, Mich.	8–9			1.06														0.64			
Devils Lake, N. Dak.	22			0.82														*			
Dodge City, Kans.	23–24			0.56														*			
Drexel, Nebr.	15			0.25														*			
Dubuque, Iowa.	15–16			1.49														0.21			
Duluth, Minn.	25–26			0.59														*			
Eastport, Me.	9			0.70														*			
Elkins, W. Va.	17			0.44														0.19			
Ellendale, N. Dak.	14			0.57														0.38			
El Paso, Tex.	23			0.28														*			
Erie, Pa.	8–9			0.45														0.24			
Escanaba, Mich.	15			1.19														*			
Eureka, Cal.	2			1.86														*			
Evansville, Ind.	16			2.71														0.27			
Flagstaff, Ariz.	22–23			0.31														0.32			
Fort Smith, Ark.	8			0.99														*			
Fort Wayne, Ind.	15			2.43														0.36			
Fort Worth, Tex.	24			1.19														*			
Fresno, Cal.	13			0.53														0.45			
Galveston, Tex.	30	5:15 p. m.	7:30 p. m.	0.99	6:08 p. m.	6:41 p. m.	0.05	0.21	0.39	0.54	0.69	0.76	0.80	0.86				0.17			
Grand Haven, Mich.	17			2.21																	
Grand Junction, Colo.	21–22			0.29														0.31			
Grand Rapids, Mich.	17			1.47														*			
Green Bay, Wis.	15–16			0.59														0.25			
Greenville, S. C.	5			0.99														*			
Hannibal, Mo.	16	D. N. a. m.	D. N. a. m.	0.64	3:04 a. m.	3:24 a. m.	0.01	0.14	0.38	0.46	0.51							0.40			
Harrisburg, Pa.	9			1.29																	
Hartford, Conn.	28			1.92														0.27			
Hatteras, N. C.	5–6			0.70														0.42			
Havre, Mont.	3–4			0.23														0.40			
Helena, Mont.	14			0.16														*			
Houghton, Mich.	15–16			0.49														*			
Houston, Tex.	16			0.75														*			
Huron, S. Dak.	14			0.40														0.49			
Independence, Cal.	19–20			0.49														*			
Indianapolis, Ind.	15			3.06														*			
Iola, Kans.	25			0.28														0.56			
Jacksonville, Fla.	11			1.79														0.22			
Kalispell, Mont.	1–2			0.29														0.58			
Kansas City, Mo.	15			0.65														*			
Keokuk, Iowa.	15–16			1.21														0.38			
Key West, Fla.	18			0.16														*			
Knoxville, Tenn.	27			1.42														0.16			
La Crosse, Wis.	15			1.77														0.37			
Lander, Wyo.	3			0.11														0.48			
Lansing, Mich.	8–9			1.41														*			
Lewiston, Idaho.	30			0.14														*			
Lexington, Ky.	16			1.30														0.11			
Lincoln, Nebr.	15			0.24														0.44			
Little Rock, Ark.	16	6:58 a. m.	6:40 p. m.	2.73	11:14 a. m.	11:53 a. m.	0.46	0.31	0.43	0.48	0.55	0.59	0.65	0.69	0.76			0.17			
Los Angeles, Cal.	13			0.95																	
Louisville, Ky.	16			2.65														0.52			
Ludington, Mich.	16			0.51														0.39			
Lynchburg, Va.	1			0.41														0.24			
Macon, Ga.	5	3:52 p. m.	7:15 p. m.	1.04	4:12 p. m.	4:44 p. m.	0.02	0.12	0.40	0.70	0.74	0.75	0.78	0.87				0.29			
Madison, Wis.	16			0.87																	
Marquette, Mich.	29–30			0.51														0.33			
																		*			

* Self-register not in use.

† Record partly estimated.

‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during March, 1919, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Memphis, Tenn.	16			9.30																	
Meridian, Miss.	5	8:05 a. m.	11:25 a. m.	0.87	8:40 a. m.	9:17 a. m.	0.04	0.16	0.28	0.33	0.37	0.52	0.55	0.60	0.64			1.21			
	8	10:40 a. m.	4:30 p. m.	0.89	11:55 a. m.	12:16 p. m.	0.17	0.08	0.13	0.26	0.58	0.60									
	17	D. N. a. m.	7:30 a. m.	1.59	3:13 a. m.	4:00 a. m.	0.05	0.16	0.28	0.46	0.66	0.76	0.82	0.88	0.97	1.04	1.10				
Miami, Fla.	14	1:50 p. m.	5:20 p. m.	3.00	1:53 p. m.	2:28 p. m.	0.15	0.11	0.13	0.14	0.30	0.39	0.46	0.50	0.59	0.69					
					3:49 p. m.	4:31 p. m.	1.39	0.14	0.39	0.59	0.79	1.08	1.24	1.30	1.38	1.43					
	14–15	9:10 p. m.	D. N. a. m.	4.03	9:28 p. m.	10:15 p. m.	0.07	0.20	0.42	0.83	1.20	1.66	2.15	2.43	2.60	2.71	2.75				
Milwaukee, Wis.	15–16			1.10																	
Minneapolis, Minn.	25			0.36														*			
Mobile, Ala.	5	11:15 a. m.	1:55 p. m.	0.67	11:36 a. m.	11:45 a. m.	0.02	0.25	0.55									*			
	8	11:20 a. m.	4:25 p. m.	1.62	3:18 p. m.	3:57 p. m.	0.75	0.06	0.13	0.15	0.20	0.26	0.39	0.60	0.80						
	17	D. N. a. m.	10:10 a. m.	1.30	6:59 a. m.	7:14 a. m.	0.59	0.23	0.42	0.57											
	26	6:35 a. m.	12:50 p. m.	1.28	9:52 a. m.	10:22 a. m.	0.63	0.08	0.14	0.21	0.28	0.47	0.53								
Modena, Utah.	21–22			0.33														*			
Montgomery, Ala.	8	8:05 a. m.	7:05 p. m.	6.01	4:07 p. m.	5:07 p. m.	3.21	0.14	0.48	0.73	0.91	0.94	1.00	1.05	1.30	1.44	1.47	1.62			
					5:44 p. m.	6:37 p. m.	4.94	0.15	0.27	0.39	0.42	0.45	0.50	0.64	0.74	0.79	0.90	1.06			
	17	7:05 a. m.	10:40 a. m.	1.66	7:14 a. m.	8:04 a. m.	T.	0.13	0.29	0.44	0.54	0.57	0.63	0.77	0.86	0.91	1.00				
Moorehead, Minn.	14			0.23														*			
Mount Tamalpais, Calif.	13			0.75														0.26			
Nantucket, Mass.	28			0.37														0.29			
Nashville, Tenn.	16			3.71														0.55			
New Haven, Conn.	1			0.98														0.60			
New Orleans, La.	5	6:40 a. m.	10:05 a. m.	0.92	8:49 a. m.	9:08 a. m.	0.14	0.18	0.47	0.55	0.64										
New York, N. Y.	1			0.80														0.53			
Norfolk, Va.	18			0.70														0.41			
Northfield, Vt.	27–28			3.38														*			
North Head, Wash.	17			1.00														0.18			
North Platte, Nebr.	24–25			0.22														*			
Oklahoma, Okla.	8			1.36														0.33			
Omaha, Nebr.	14–15			1.00														*			
Oswego, N. Y.	9			0.92														*			
Palestine, Tex.	16	11:55 a. m.	2:55 p. m.	1.07	12:26 p. m.	1:21 p. m.	0.04	0.07	0.10	0.20	0.24	0.54	0.59	0.70	0.72	0.78	0.84	0.94			
Parkersburg, W. Va.	8			0.65														0.26			
Pensacola, Fla.	26			1.16														0.43			
Peoria, Ill.	15	9:55 a. m.	2:20 p. m.	1.55	10:14 a. m.	10:34 a. m.	0.01	0.21	0.33	0.50	0.55										
Philadelphia, Pa.	27			1.78														0.53			
Phoenix, Ariz.	15			0.79														0.30			
Pierre, S. Dak.	14			0.60														*			
Pittsburgh, Pa.	8–9			0.65														0.19			
Pocatello, Idaho.	2			0.25														0.09			
Point Reyes Light, Calif.	12			0.42														0.22			
Port Angeles, Wash.	17			0.30														0.09			
Port Huron, Mich.	8–9			0.69	*													*			
Portland, Me.	9			1.30														0.49			
Portland, Oreg.	2			0.49														0.21			
Providence, R. I.	9			1.40														*			
Pueblo, Colo.	22–23			0.54														*			
Raleigh, N. C.	5			0.51														0.38			
Rapid City, S. Dak.	14			0.38														*			
Reading, Pa.	9			1.91														0.44			
Red Bluff, Calif.	2			0.75														0.57			
Reno, Nev.	21			0.38														*			
Richmond, Va.	9			0.67														0.47			
Rochester, N. Y.	9			0.83														*			
Roseburg, Oreg.	11			0.86														0.18			
Roswell, N. Mex.	21			2.97														0.54			
Sacramento, Calif.	12			0.32														0.23			
Saginaw, Mich.	17			0.91														0.17			
St. Joseph, Mo.	15–16	11:05 a. m.	7:30 a. m.	5.01	1:07 p. m.	1:57 p. m.	0.22	0.10	0.17	0.24	0.33	0.37	0.38	0.45	0.53	0.58	0.63				
					1:57 p. m.	2:47 p. m.	.....	0.69	0.81	0.95	0.99	1.03	1.08	1.10	1.12	1.14	1.22				
					2:47 p. m.	3:17 p. m.	.....	1.29	1.41	1.45	1.50	1.53	1.68	.....							
					7:17 p. m.	8:47 p. m.	2.43	0.21	0.42	0.44	0.45	0.50	0.60	0.77	0.87	1.14	1.22	1.37	1.70	1.85	
St. Louis, Mo.	16			0.39														0.34			
St. Paul, Minn.	25			0.35														*			
Salt Lake City, Utah.	2–3			0.25														*			
San Antonio, Tex.	5			0.30														0.30			
San Diego, Calif.	20			0.98														0.39			
Sandusky, Ohio.	15			1.07														0.20			
Sandy Hook, N. J.	1			0.53														0.30			
San Francisco, Calif.	12			0.66														0.35			
San Jose, Calif.	12			0.57														0.22			
San Luis Obispo, Calif.	13			2.06														0.58			
Santa Fe, N. Mex.	21			0.79														*			
Sault Ste. Marie, Mich.	15–16			0.69														*			
Savannah, Ga.	2			1.42														0.44			
Scranton, Pa.	27–28			0.97														*			
Seattle, Wash.	17			0.51														0.08			
Sheridan, Wyo.				0.15														*			
Shreveport, La.	8	6:44 a. m.	9:10 a. m.	0.60	6:59 a. m.	7:25 a. m.	0.01	0.06	0.15	0.31	0.44	0.51	0.54								
Sioux City, Iowa.	14			0.46														*			
Spokane, Wash.	17–18			0.32														*			
Springfield, Ill.	15			0.34														0.21			
Springfield, Mo.	8			1.18														*			
Syracuse, N. Y.	27–28			1.24														*			
Tacoma, Wash.	17			0.89														0.19			
Tampa, Fla.	7–8	8:50 p. m.	D. N. a. m.	1.69	8:54 p. m.	9:28 p. m.	0.01	0.09	0.16	0.45	0.63	0.78	0.90	0.99							
Tatoosh Island, Wash.	17			1.44														0.29			
Taylor, Tex.	8			0.42														0.33			
Terre Haute, Ind.	16			1.21														0.51			
Thomasville, Ga.	8–9	4:00 p. m.	D. N. a. m.	4.40	10:29 p. m.	11:13 p. m.	0.66	0.31	0.63	0.83	1.10	1.21	1.35	1.45	1.55	1.60					
					1:24 a. m.	1:48 a. m.	2.86	0.10	0.28	0.66	1.12	1.33									
Toledo, Ohio.	26			0.73														0.17			
Tonopah, Nev.	20–21			0.53														*			
Topeka, Kans.	15	11:53 a. m.	11:59 p. m.	5.10	12:57 p. m.	1:31 p. m.	0.03	0.08	0.11	0.27	0.41	0.46	0.51	0.56							
					2:05 p. m.	3:27 p. m.	0.82	0.06	0.14	0.26	0.49	0.63	0.68	0.74	0.97	1.04	1.08	1.32	1.71	1.73	
Trenton, N. J.	27			1.83														0.63			
Valentine, Nebr.	14			0.18														*			
Vicksburg, Miss.	5	D. N. a. m.	10:10 a. m.	2.68	2:22 a. m.	2:44 a. m.	0.04	0.13	0.23	0.33	0.54	0.61									
					3:57 a. m.	5:28 a. m.	0.78	0.26	0.39	0.43	0.58	0.65	0.70	0.77	0.82	0.86	0.89	1.10	1.29	1.50	

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† Record partly estimated.

‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during March, 1919, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Walla Walla, Wash.	18			0.77														0.13			
Washington, D. C.	27	3:15 a.m.	2:30 p.m.	1.34	12:41 p.m.	1:18 p.m.	0.64	0.05	0.18	0.31	0.36	0.38	0.43	0.58	0.62						
Wausau, Wis.	15			0.56														*			
Wichita, Kans.	15			1.80														*			
Williston, N. Dak.	2-3			0.53														*			
Wilmington, N. C.	18			0.72														0.48			
Winnemucca, Nev.	6			0.29														*			
Wytheville, Va.	27			0.59														0.22			
Yankton, S. Dak.	6-7			0.50														*			
Yellowstone Park, Wyo.	13-14			0.32														*			

*Self-register not in use. †Record partiy estimated. ‡No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, March, 1919.*

Stations.	Altitude above mean sea level Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷ 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	30.04	30.08	+0.20	29.6	+ 3.4	36.8	22.4	47	8	5.33	+0.40	0.5
Halifax, N. S.	88	29.96	30.07	+ .13	32.8	+ 3.8	39.9	25.8	59	10	4.51	−0.95	3.0
Yarmouth, N. S.	65	29.97	30.04	+ .09	35.5	+ 4.7	42.2	28.7	66	14	3.64	−1.21	2.1
Charlottetown, P. E. I.	38	30.02	30.06	+ .16	28.3	+ 2.9	34.2	22.4	42	5	3.56	+0.35	3.0
Chatham, N. B.	28	30.08	30.10	+ .20	27.3	+ 4.3	36.7	18.0	49	− 6	4.89	+1.42	16.6
Father Point, Que.	20	30.10	30.12	+ .22	24.7	+ 4.4	32.4	17.0	50	− 7	2.14	−0.59	15.5
Quebec, Que.	296	29.79	30.13	+ .17	26.4	+ 5.2	34.2	18.6	50	− 9	4.71	+1.45	28.6
Montreal, Que.	187	29.92	30.14	+ .14	28.1	+ 4.3	35.4	20.7	54	− 1	6.26	+2.47	43.2
Stonecliffe, Ont.	489	29.55	30.18	+ .17	19.1	+ 0.1	37.1	1.2	54	−18	1.56	−0.50	4.0
Ottawa, Ont.	236	29.90	30.18	+ .17	27.0	+ 5.5	36.9	17.1	50	− 8	4.34	+1.62	23.4
Kingston, Ont.	285	29.85	30.18	+ .17	31.0	+ 5.4	39.4	22.6	58	3	3.80	+1.16	14.2
Toronto, Ont.	379	29.76	30.19	+ .17	33.8	+ 6.5	42.1	25.5	56	7	3.19	+0.55	6.8
Cochrane, Ont.	930				18.1		30.2	6.0	53	−27	0.70		6.0
White River, Ont.	1,244	28.79	30.16	+ .13	18.0	+ 5.8	31.8	4.2	48	−36	1.07	−0.31	7.4
Port Stanley, Ont.	592	29.51	30.17	+ .14	33.2	+ 6.0	41.1	25.4	52	14	3.64	+0.76	10.7
Southampton, Ont.	656	29.45			30.5	+ 5.8	38.7	22.2	62	4	2.81	+0.16	16.5
Parry Sound, Ont.	688	29.48	30.20	+ .18	27.7	+ 6.6	38.4	17.1	55	− 5	2.04	−0.19	2.0
Port Arthur, Ont.	644	29.46	30.20	+ .15	22.7	+ 5.9	33.0	12.4	46	−15	1.32	+0.35	9.7
Winnipeg, Man.	760	29.28	30.15	+ .06	15.5	+ 3.2	24.8	6.3	40	−28	1.72	+0.69	12.9
Minnedosa, Man.	1,690	28.24	30.16	+ .10	10.9	− 1.6	21.6	0.3	40	−32	1.12	+0.47	11.2
Le Pas, Man.	860				7.8		20.7	−5.1	49	−32	0.30		3.0
Qu'Appelle, Sask.	2,115	27.74	30.10	+ .06	11.9	− 3.0	22.0	1.8	41	−28	1.32	+0.55	13.2
Medicine Hat, Alb.	2,144	27.66	30.01	+ .01	19.8	− 7.7	32.0	7.7	58	−32	0.53	−0.23	5.3
Moose Jaw, Sask.	1,759				14.9		26.5	3.3	55	−28	1.05		10.5
Swift Current, Sask.	2,392	27.38	30.13	+ .11	15.6	− 6.4	26.1	5.2	60	−26	0.92	+0.11	9.2
Calgary, Alb.	3,428	26.36	30.08	+ .13	19.4	− 6.8	29.4	9.4	58	−33	0.55	−0.17	5.5
Banff, Alb.	4,521	25.26	30.02	+ .08	18.5	− 1.7	32.7	4.2	56	−40	1.84	+0.43	18.4
Edmonton, Alb.	2,150	27.66	30.06	+ .10	13.7	−10.5	25.0	2.4	52	−32	0.59	−0.13	5.0
Prince Albert, Sask.	1,450	28.48	30.14	+ .06	10.0	− 2.0	21.5	−1.5	42	−26	0.82	+0.05	8.2
Battleford, Sask.	1,592	28.29	30.13	+ .07	9.4	− 3.7	20.8	1.9	46	−32	0.57	+0.11	5.7
Kamloops, B. C.	1,262	28.72	30.04	+ .12	34.1	− 2.0	43.7	24.5	68	− 2	1.10	+0.53	10.7
Victoria, B. C.	230	29.73	29.99	+ .02	43.9	+ 2.0	49.9	38.0	62	−32	2.22	−0.90	T.
Barkerville, B. C.	4,180	25.54	29.94	+ .06	21.2	− 4.9	30.9	11.5	51	−21	3.77	+1.88	36.8
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.94	30.11	+ .03	62.2	0.0	67.4	57.0	72	51	2.17	−2.96	

SEISMOLOGICAL TABLES.

SEISMOLOGICAL REPORTS FOR MARCH, 1919.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., May 2, 1919.]

TABLE 1.—*Noninstrumental earthquake reports, March, 1919.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
	H. m.	CALIFORNIA.	° ′	° ′			*Sec.*			
Mar. 1	4 19	Lonoak	36 20	120 55	4	1	.....	.....	.....	M. L. Griffin.
7		Brawley	32 59	115 40	4	1	.....	None	.....	M. D. Witter.
15	7 53	San Luis Obispo	35 18	120 39	3–4	1	.....	do	Awakened people	U. S. Weather Bureau.
15	10 31	Calexico	32 41	115 30	4	1	8	Rumbling	Preceded by roaring	H. M. Rouse.
15	10 40	Calexico	32 41	115 30	4	1	.....	.....	Buildings creaked	Do.
19	6 06	Calexico	32 41	115 30	3	1	½	Rumbling	Abrupt lurch to northeast	Do.
21	11 00	Squirrel Inn	34 07	117 19	4	1	.....	None	.....	Mrs. Sarah Frantz.
27	7 50	Hemet	33 45	116 56	5	1	2	Rumbling	.....	C. E. McManigal.

TABLE 2.—*Instrumental reports, March, 1919.*

(Time used: Greenwich, midnight to midnight. Nomenclature: International.)

[For significance of symbols see REVIEW for January, 1919, p. 59.]

Alabama. *Mobile. Spring Hill College.* Earthquake Station. Cyril Ruhlmann, S. J.

Lat., 30° 41′ 44″ N.; long., 88° 08′ 46″ W. Elevation, 60 meters.

Instrument: Wiechert 80 kg.; astatic, horizontal pendulum.

(No earthquake recorded during March, 1919.)

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: {E V 10, T_0 15; N V 10, T_0 15}

(No earthquake recorded during March, 1919.)

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. H. Cullum.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: {E V 10, T_0 14; N 10 18}

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1919.			*H. m. s.*	*Sec.*	*a*	*a*	*Km.*	
Mar. 9	.....	P	4 42 00	2	10	10	.....	Apparently a slight near-by shock.
		F	4 45 00	4	.....	.....	.....	

California. *Berkeley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 19″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1919.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Mar. 5	.....	.....	.....	.....	*50	*100	.....	Tremors during 24 hours preceding 16h 00m to 28th and 15h 00m to 31st, on dates given.
12	.....	.....	.....	.....	*50	*50	.....	
18	.....	.....	.....	.....	*100	*150	.....	
20	.....	.....	.....	.....	*100	*100	.....	
21	.....	.....	.....	.....	*100	*100	.....	
24	.....	.....	.....	.....	*100	*100	.....	
25	.....	.....	.....	.....	*100	*150	.....	
26	.....	.....	.....	.....	*100	*100	.....	
28	.....	.....	.....	.....	*100	*100	.....	
30	.....	.....	.....	.....	*100	*100	.....	
31	.....	.....	.....	.....	*50	*50	.....	

*Amplitude on instrument.

California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 63″ W. Elevation, 27.43 meters.

(See record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver. Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1919.			*H. m. s.*	*Sec.*	*μ*	*μ*	*km.*	
Mar. 14	.....	L_N	18 40 ..	.....	.....	.....	.....	Very strong activity at intervals during day. Stronger on N–S.
		F_N	22 30 ..	.....	.....	.....	.....	
15	.....	L_N	19 42 ..	.....	.....	.....	.....	Distinct but too small to be analyzed.
		F_N	19 51 ..	.....	.....	.....	.....	
23	.....	L_N	2 27 ..	.....	.....	.....	.....	Small and indistinct.
		F_N	2 37 ..	.....	.....	.....	.....	
31	.....	L_N	12 10 ..	.....	.....	.....	.....	Distinct activity, especially at hours marked. Somewhat doubtful as to being seismic.
		F_N	12 40 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports, March, 1919*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
District of Columbia. *Washington, U. S. Weather Bureau.*								
Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.								
Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.								
Instrumental constants.. V 110, T_0 6.4								
1919 Mar. 2	.....	P.....	*H. m. s.* 3 39 00	*Sec.*	μ	μ	*km.* 9,010	
		S.....	3 49 11	.....	.....	.....	.....	
		eL.....	4 08 10	24	.....	.....	.....	
		L.....	4 18 00	20	.....	.....	.....	
		F.....	4 30 00	.....	.....	.....	.....	
2	.....	P.....	11 57 26	.....	.....	.....	8,840	
		S.....	12 07 28	.....	.....	.....	.....	
		SR_1...	12 13 00	.....	.....	.....	.....	
		L_E...	12 20 50	20	.....	.....	.....	
		L.....	12 27 00	20	.....	.....	.....	
		L.....	12 36 00	20	.....	.....	.....	
		F.....	13 00 ..	.....	.....	.....	.....	
9	.....	P_N...	3 29 07	.....	.....	.....	8,790	Scarcely visible on E–W.
		S_N...	3 39 07	.....	.....	.....	.....	
		eL.....	3 59 00	.....	.....	.....	.....	
		F.....	4 30 ..	.....	.....	.....	.....	
21	.....	eL.....	17 03 00	28	.....	.....	.....	
		L.....	17 09 00	20	.....	.....	.....	
		F.....	17 30 ..	.....	.....	.....	.....	
District of Columbia. *Washington. Georgetown University.*								
F, A, Tondorf. S, J,								
Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.								
Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.								
Instrumental constants..			V	T_0	e			
		E	165	5.4	0			
		N	143	5.2	0			
		Z	*80*	*3.0*	*0*			
1919 Mar. 2	.....	eP_E...	*H. m. s.* 3 39 05	*Sec.*	μ	μ	*km.*	Heavy microseisms. No distinct main. F doubtful.
		iP_N...	3 39 05	.....	.....	.....	.....	
		iS_N...	3 49 18	.....	.....	.....	.....	
		eS_N...	3 49 18	.....	.....	.....	.....	
		eL_E...	4 02 24	22	.....	.....	.....	
		L_E...	4 13 09	.....	.....	.....	.....	
		L_N...	4 18 09	21	.....	.....	.....	
		F.....	4 50 ..	.....	.....	.....	.....	
2	.....	eP_N...	11 57 26	.....	.....	.....	.....	Heavy microseisms. No distinct main. F?, difficult.
		eP_E...	11 57 46	.....	.....	.....	.....	
		S_E...	12 07 45	.....	.....	.....	.....	
		eL_E...	12 21 12	32	.....	.....	.....	
		L_E...	12 28 08	22	.....	.....	.....	
		L_N...	12 30 57	16	.....	.....	.....	
9	.....	S.....	3 39 12	.....	.....	.....	.....	e is so masked in microseisms that interpretation is impossible. F?
		eL_E...	3 59 54	22	.....	.....	.....	
21	.....	eL.....	17 13 12	26	.....	.....	.....	Heavy microseisms.
		L_E...	17 15 02	22	.....	.....	.....	
		F.....	17 27 ..	.....	.....	.....	.....	

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Frank Neumann.								
Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.								
Instrument: Milne seismograph of the Seismological Committee of the British Association.								
Instrumental constant..18.4. Sensitivity, 0.40″.								
1918. Mar. 1	.....	L.....	*H. m. s.* 14 09 00	*Sec.*	μ	μ	*Km.*	
		M.....	14 13 30	.....	* 200	.....	.....	
		F.....	14 17 ..	.....	.....	.....	.....	
2	.....	eP.....	3 51 48	.....	.....	.....	.....	Periods uncertain. Paper moving irregularly.
		S.....	3 59 06	.....	.....	.....	.....	
		L.....	4 14 30	.....	.....	.....	.....	
		M.....	4 19 00	.....	*2,600	.....	.....	
		C.....	4 27 ..	.....	.....	.....	.....	
		F.....	6 25 ..	.....	.....	.....	.....	
2	.....	P.....	12 09 06	19	.....	.....	.....	
		S.....	12 17 06	20	.....	.....	.....	
		L.....	12 32 00	.....	.....	.....	.....	
		M.....	12 37 00	16	*3,900	.....	.....	
		C.....	12 39 ..	.....	.....	.....	.....	
		F.....	14 41 ..	.....	.....	.....	.....	
4	.....	eL.....	8 48 00	.....	.....	.....	.....	
		M.....	8 50 ..	.....	*100	.....	.....	
		F.....	8 53 ..	.....	.....	.....	.....	
5	.....	eL.....	20 17 00	.....	.....	.....	.....	
		M.....	20 21 30	.....	*100	.....	.....	
		F.....	20 30 ..	.....	.....	.....	.....	
9	.....	P.....	3 42 36	18	.....	.....	.....	
		S.....	3 50 48	19	.....	.....	.....	
		eL.....	4 03 00	24	.....	.....	.....	
		M.....	4 09 42	21	*900	.....	.....	
		C.....	4 12 ..	21	.....	.....	.....	
		F.....	6 10 ..	.....	.....	.....	.....	
10	.....	P.....	21 38 42	20	.....	.....	.....	
		eL.....	21 55 ..	19	.....	.....	.....	
		M.....	22 05 ..	.....	*100	.....	.....	
		F.....	22 08 ..	.....	.....	.....	.....	
14	.....	eL.....	15 06 ..	.....	.....	.....	.....	
		M.....	15 09 42	20	*100	.....	.....	
		F.....	15 23 ..	.....	.....	.....	.....	
16	.....	P.....	7 44 00	20	.....	.....	.....	
		S.....	7 53 54	18	.....	.....	.....	
		eL.....	8 06 ..	.....	.....	.....	.....	Beginning of L confused.
		M.....	8 16 48	20	*600	.....	.....	
		C.....	8 26 ..	19	.....	.....	.....	
		F.....	8 54 ..	.....	.....	.....	.....	
19	.....	eL.....	11 30 00	.....	.....	.....	.....	
		M.....	11 34 30	.....	*100	.....	.....	
		F.....	11 38 ..	.....	.....	.....	.....	
21	.....	eP.....	1 39 00	.....	.....	.....	.....	P faint and uncertain.
		L.....	1 44 00	.....	.....	.....	.....	
		M.....	1 49 30	21	*300	.....	.....	
		C.....	1 55 00	20	.....	.....	.....	
		F.....	2 02 ..	.....	.....	.....	.....	
21	.....	eP.....	16 27 00	.....	.....	.....	.....	Preceded and followed by tremors extending to the next quake.
		S.....	16 29 00	.....	.....	.....	.....	
		eL.....	16 30 12	.....	.....	.....	.....	
		M.....	16 35 00	17	*1,800	.....	.....	
		C.....	16 38 ..	16	.....	.....	.....	
21	.....	P.....	17 55 06	.....	.....	.....	.....	
		S.....	17 58 12	.....	.....	.....	.....	
		eL.....	18 00 00	.....	.....	.....	.....	
		M.....	18 03 06	17	*800	.....	.....	
		C.....	18 10 ..	16	.....	.....	.....	
		F.....	18 49 ..	.....	.....	.....	.....	
22	.....	eL.....	16 44 00	.....	.....	.....	.....	Followed by tremors.
		M.....	16 49 12	16	*200	.....	.....	
		C.....	16 52 ..	.....	.....	.....	.....	
		F.....	17 02 ..	.....	.....	.....	.....	
30	.....	eL.....	11 10 00	.....	.....	.....	.....	Two series of long waves.
		M.....	11 15 30	.....	*300	.....	.....	
		C.....	11 25 ..	.....	.....	.....	.....	
		F.....	11 30 ..	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental reports, March, 1919*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Illinois. *Chicago.* University of Chicago. U. S. Weather Bureau.								
Lat., 41° 47′ N.; long., 87° 37′ W. Elevation, 180.1 meters.								
Instruments: Two Milne-Shaw horizontal pendulums, 0.45 kg.								
				V	T_0	ϵ	Sensitivity.	
Instrumental constants..				E 150	12	20:1	1″arc tilt=26.6 mm.	
				N 150	8	20:1	1″arc tilt=13.2 mm.	
1919. Mar. 2	.....	P.....	*H. m. s.* 3 39 21	*Sec.*	.....	.....	9,160	Record very well defined.
		S.....	3 49 40	.....	.....	.....	.....	
		L?....	4 02 12	.....	.....	.....	.....	
		L.....	4 11 00	30	.....	.....	.....	On March 6th T_0 on both instruments set to 12 sec. Sensitivity, 28 mm.
		L.....	4 15 00	25	.....	.....	.....	
		L.....	4 31 00	20	.....	.....	.....	
		F.....	6 30 ..	.....	.....	.....	.....	
2	.....	P.....	11 57 49	.....	.....	.....	9,085	Well defined record.
		S.....	12 08 04	.....	.....	.....	.....	
		L.....	12 20 42	.....	.....	.....	.....	
		L.....	12 30 00	30	.....	.....	.....	
		L.....	12 43 30	20	.....	.....	.....	
		L.....	12 50 ..	15	.....	.....	.....	
		F.....	15 30 ..	.....	.....	.....	.....	
9	.....	P.....	3 29 18	.....	.....	.....	9,395	P not well defined.
		S.....	3 39 48	.....	.....	.....	.....	
		L?....	3 55 00	24	.....	.....	.....	
		L.....	4 01 00	30	.....	.....	.....	
		L.....	4 19 ..	16	.....	.....	.....	F in microseisms, 5^h.
21	.....	eL.....	16 56 ..	30	.....	.....	.....	Other phases not discernible. Very heavy microseisms.
		L.....	17 11 ..	20	.....	.....	.....	
22	.....	S?.....	16 46 30	.....	.....	.....	.....	
		eL.....	17 14 ..	24	.....	.....	.....	
		F.....	17 50 ..	.....	.....	.....	.....	
25	.....	P.....	3 45 57	.....	.....	.....	2,150	
		S.....	3 49 33	.....	.....	.....	.....	
		L.....	3 50 15	.....	.....	.....	.....	
		F.....	4 20 ..	.....	.....	.....	.....	
26	.....	eL.....	10 45 20	24	.....	.....	.....	Not on N–S. Possibly not seismic.
		L.....	10 51 ..	15	.....	.....	.....	
		F.....	11 20 ..	.....	.....	.....	.....	
Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.								
Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.								
Instrument: Wiechert.								
				V	T_0	ϵ		
Instrumental constants..				E 177	3.4	4:1		
				N 205	3.4	4:1		
(Report for March, 1919, not received.)								
Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.								
Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.								
Instruments: Two Bosch-Omori, 10 and 12 kg.								
				V	T_0			
Instrumental constants..				E 10	14			
				N 10	14			
1918. Mar. 2	.....	P_N.....	*H. m. s.* 3 39 21	*Sec.* 3	.....	.....	.....	No long waves on E–W; a few only on N–S.
		eP_E...	3 40 01	3	.....	.....	.....	
		S.....	3 49 33	8	.....	.....	.....	
		M.....	3 49 45	.....	20	10	.....	
		eL_N...	4 18 30	20	.....	.....	.....	
		F_N....	4 38 ..	.....	.....	.....	.....	
2	.....	eP_N...	12 07 45	.....	.....	.....	.....	
		eP_E...	12 07 47	.....	.....	.....	.....	
		eL_E...	12 28 39	.....	.....	.....	.....	
		eL_N...	12 30 38	.....	.....	.....	.....	
		M_E....	12 31 54	20	10	.....	.....	
		M_N....	12 37 00	20	.....	20	.....	
		F.....	12 45 ..	.....	.....	.....	.....	
9	.....	P_E....	3 38 44	.....	.....	.....	.....	Record very faint with the exception of P.
		P_N....	3 38 47	.....	.....	.....	.....	
		eL_E...	4 00 39	.....	.....	.....	.....	
		eL_N...	4 01 43	.....	.....	.....	.....	
		F_E....	4 27 ..	.....	.....	.....	.....	
		F_N....	4 32 ..	.....	.....	.....	.....	
Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.								
Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.								
Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).								
				V	T_0	ϵ		
Instrumental constants..				E 80	23	0		
				N 50	25	4:1		
1919. Mar. 2	.....	O.....	*H. m. s.* *3 26.59*	*Sec.*	.....	.....	*km.* 9,150	P_E masked by microseisms. eL faint and difficult to fix. eL?—S gives Δ=9860. E-W damped 1.5:1.
		iP'_N...	3 39 19	6	.....	.....	.....	
		S_N....	3 39 37	6	.....	.....	.....	
		S_E....	3 49 49	10	.....	.....	.....	
		i_E....	3 54 39	10	.....	.....	.....	
		eL_N?..	4 08 39	.....	.....	.....	.....	
		eL_E?..	4 09 07	.....	.....	.....	.....	
		L_N....	4 09 26	40	.....	.....	.....	
		L_E?...	4 10 19	20	.....	.....	.....	
		M_N?...	4 13 55	20	.....	.....	.....	
		L_N....	4 24 14	16	.....	.....	.....	
		L_E....	4 26 50	18–20	.....	.....	.....	
		F.....	5 23 11	.....	.....	.....	.....	
2	.....	O.....	*11 45 27*	.....	.....	.....	9,230	Probably from same epicenter as preceding "homocentric."
		iP'_N...	11 57 51	.....	.....	.....	.....	
		P_E?...	11 57 ..	.....	.....	.....	.....	
		S.....	12 08 13	.....	.....	.....	.....	
		i_E....	12 08 23	20	.....	.....	.....	N-shaped wave, i from east.
		i_N....	12 08 29	16	.....	.....	.....	N-shaped wave, i from north.
		e_E....	12 13 13	20	.....	.....	.....	
		eL_E...	12 27 15	30	.....	.....	.....	
		eL_N...	12 27 51	40	.....	.....	.....	
		M_E....	12 29 ..	28	.....	.....	.....	Faint maxima.
		M_N....	12 31 55	25	.....	.....	.....	
		F_N....	13 29 ..	.....	.....	.....	.....	
		F_E....	14 24 ..	.....	.....	.....	.....	
9	.....	O.....	*3 17 00*	.....	.....	.....	9,230	Probably same epicenter as two preceding.
		iP'_N...	3 29 24	.....	.....	.....	.....	
		S_N....	3 39 46	.....	.....	.....	.....	
		S_E....	3 39 52	.....	.....	.....	.....	
		eL_E...	3 59 20	30	.....	.....	.....	eL_N not clear.
		L_E....	4 02 14	20	.....	.....	.....	
		M_E?...	4 11 38	15+	.....	.....	.....	
		F.....	5 06 ..	.....	.....	.....	.....	
14	.....							E-W out of commission, 11^h 56^m–13^h $42.^m$
22	.....	e_E....	16 57 50	.....	.....	.....	.....	
		L_E....	17 04 25	30	.....	.....	.....	Sinusoidal.
		L_E?...	17 04 39	25	.....	.....	.....	
		F.....	17 50 ..	.....	.....	.....	.....	
Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.								
Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.								
Instrument: Wiechert 80 kg. astatic, horizontal pendulum.								
				V	T_0	ϵ		
Instrumental constants..				80	7	5:1		
(Report for March, 1919, not received.)								
New York. *Ithaca. Cornell University.* Heinrich Ries.								
Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.								
Instruments: Two, Bosch-Omori, 25 kg.. horizontal pendelums (mechanical registration).								
				V	T_0	ϵ		
Instrumental constants..				E 13	22	4:1		
				N 14	25	4:1		
1919. Mar. 2	.....	P_N.....	*H. m. s.* 3 39 18	*Sec.* 5	.....	.....	*km.*	
		S_E.....	3 49 40	8	.....	.....	.....	
		eL_E...	4 01 50	22	.....	.....	.....	
		F_E....	4 48 ..	.....	.....	.....	.....	
2	.....	e_N.....	12 08 07	4	.....	.....	.....	
		e_E.....	12 08 16	6	.....	.....	.....	
		e_E.....	12 13 45	20	.....	.....	.....	
		eL_E...	12 23 20	22	.....	.....	.....	
		F_E....	13 47 ..	.....	.....	.....	.....	
9	.....	e_E.....	3 39 31	6	.....	.....	.....	
		e_N.....	3 39 40	6	.....	.....	.....	
		eL_E...	3 55 38	18	.....	.....	.....	
		F_N....	4 36 ..	.....	.....	.....	.....	
21	.....	L_N....	17 01 28	30	.....	.....	.....	
		L_E....	17 02 56	30	.....	.....	.....	
		F_E....	17 28 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports, March, 1919*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Panama Canal. *Balboa Heights.* Governor, Panama Canal.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants.. V 35, T_0 20

1919.			H. m. s.	Sec.	μ	μ	km.	
Mar. 4	.....	P_N	3 14 48	.....	.....	.....	370	
		P_E	3 14 50	.....	.....	.....	.....	
		L_N	3 15 34	.....	.....	.....	.....	
		L_E	3 15 41	.....	.....	.....	.....	
		M_N	3 15 42	.....	.....	*1,500	.....	
		M_E	3 15 49	.....	*1,000	.....	.....	
		F	3 23 00	.....	.....	.....	.....	
26	.....	P_E	5 30 36	.....	.....	.....	500	
		P_N	5 30 41	.....	.....	.....	.....	
		S_E	5 31 24	.....	.....	.....	.....	
		S_N	5 31 26	.....	.....	.....	.....	
		L_E	5 31 41	.....	.....	.....	.....	
		L_N	5 31 43	.....	.....	.....	.....	
		M_E	5 31 44	.....	*2,400	.....	.....	
		M_N	5 31 49	.....	.....	*5,000	.....	
		F	5 39 ..	.....	.....	.....	.....	

* Trace amplitude.

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wallace M. Hill.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants.. V: E 10, N 10; T_0: E 17, N 19

1919.			H. m. s.	Sec.	μ	μ	km.	
Mar. 2	.....	eL_E	3 59 39	24	.....	.....	.....	
		M_E	4 03 30	18	20	.....	.....	
		eL_N	4 05 32	.....	.....	.....	.....	
		M_N	4 08 31	15	.....	20	.....	
		F	4 10 ..	.....	.....	.....	.....	
2	.....	eP_E	11 58 46	.....	.....	.....	.....	
		L_E	12 18 12	22	.....	.....	.....	
		M_E	12 21 56	18	70	.....	.....	
		L_N	12 23 10	.....	.....	.....	.....	
		M_N	12 25 43	18	.....	60	.....	
		C_N	12 27 ..	18	.....	.....	.....	
		C_E	12 30 ..	18	.....	.....	.....	
		F_N	12 30 ..	.....	.....	.....	.....	
		F_E	12 37 ..	.....	.....	.....	.....	
9	.....	L_E	3 49 56	26	.....	.....	.....	
		M_E	3 51 50	22	20	.....	.....	
		L_N	3 56 56	.....	.....	.....	.....	
		M_N	3 57 36	17	.....	10	.....	
		F	4 01 ..	.....	.....	.....	.....	
24	.....	P_N	20 29 33	2	.....	.....	.....	
		P_E	20 29 39	2	.....	.....	.....	
		M_N	20 30 07	.....	.....	25	.....	
		M_E	20 30 16	.....	15	.....	.....	
		F_N	20 33 ..	.....	.....	.....	.....	
		F_E	20 34 ..	.....	.....	.....	.....	

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. V: E 10, N 10; T_0: E 15, N 16

(No earthquake recorded during March, 1919.)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoye 80 kg. vertical seismograph.

Instrumental constants.. V 120, T_0 26

1919.			H. m. s.	Sec.	μ	μ	km.	
Mar. 2	.....	*O*.....	*3 27 11*	.....	.....	.....	9,260	
		iP_N	3 39 36	.....	.....	.....	.....	
		eS_N	3 49 59	.....	.....	.....	.....	
		eS_E	3 50 14	.....	.....	.....	.....	
		eL.....	4 10 ..	40	.....	.....	.....	
		L.....	4 15 ..	25	.....	.....	.....	
		L.....	4 25 ..	17	.....	.....	.....	
		L.....	4 30 ..	19	.....	.....	.....	
		L.....	4 40 ..	17	.....	.....	.....	F in microseisms, 5h.
2	.....	*O*.....	*11 45 21*	.....	.....	.....	9,520	
		eP_N	11 58 00	.....	.....	.....	.....	
		S.....	12 08 36	.....	.....	.....	.....	
		SR_1	12 14 42	.....	.....	.....	.....	
		L.....	12 27 ..	.....	.....	.....	.....	
		L.....	12 30 ..	30	.....	.....	.....	
		L.....	12 40 ..	20	.....	.....	.....	
		L.....	12 50 ..	17	.....	.....	.....	
		L.....	13 00 ..	14	.....	.....	.....	
		L.....	13 15 ..	13	.....	.....	.....	
		L_N.....	13 40 ..	16	.....	.....	.....	F in microseisms, 148 00m.
9	.....	*O*.....	*3 17 10*	.....	.....	.....	9,380	The three quakes bear a remarkable resemblance to one another in general appearance in all phases. The values are as read but the exact second for S is difficult to determine and the difference in △ is probably due to this.
		P_N.....	3 29 42	.....	.....	.....	.....	
		PR_{1N}	3 33 12	.....	.....	.....	.....	
		S_N.....	3 40 11	.....	.....	.....	.....	
		S_E.....	3 40 25	.....	.....	.....	.....	
		eL_E	4 00 ..	24	.....	.....	.....	
		L.....	4 12 ..	20	.....	.....	.....	
		L.....	4 20 ..	18	.....	.....	.....	
		L.....	4 27 ..	15	.....	.....	.....	
		L.....	4 35 ..	16	.....	.....	.....	
		.....	.....	.....	.....	.....	.....	F in microseisms, 5h..
16	.....	e?.....	8 10 24	.....	.....	.....	.....	Heavy microseisms.
		eL_E	8 30 .. / 8 55 ..	30-20	.....	.....	.....	
		F.....	9 00 ..	.....	.....	.....	.....	
17	.....	eL.....	8 30 .. / 8 37 ..	20	.....	.....	.....	
21	.....	eL.....	17 02 .. / 17 25 ..	18	.....	.....	.....	Heavy wind tremors and microseisms. L waves of small amplitude.
22	.....	eL.....	17 24 .. / 17 30 ..	18	.....	.....	.....	Barely discernible.
25	.....	i.....	3 51 24	.....	.....	.....	.....	May not be seismic.
		e.....	3 52 .. / 4 00 ..	.....	.....	.....	.....	
26	.....	eL.....	10 48 .. / 10 59 ..	28	.....	.....	.....	Very small; barely discernible.

TABLE 2.—*Instrumental reports, March, 1919*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Canada. *Toronto. Dominion Meteorological Service.*								
Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.								
Instrument: Milne horizontal pendulum, North; in the meridian.								
Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.45″.								
1919. Mar. 2	.....	PR?..	*H. m. s.* 3 46 36	*Sec.*	.....	.....	.....	Real P possibly not recorded. Times doubtful.
		eS.....	3 50 42	.....	.....	.....	.....	
		L.....	4 07 48	.....	.....	.....	.....	
		eL.....	4 34 00	.....	.....	.....	.....	
		M.....	4 40 06	.....	*1,800	.....	.....	
		L.....	6 06 42?	.....	.....	.....	.....	
		F.....	6 09 48	.....	.....	.....	.....	
2	.....	P.....	12 01 06?	.....	.....	.....	.....	S waves fairly large. Times doubtful.
		iS.....	12 09 18	.....	.....	.....	.....	
		S.....	12 11 00	.....	.....	.....	.....	
		S.....	12 15 24	.....	.....	.....	.....	
		eL.....	12 26 12	.....	.....	.....	.....	
		L.....	12 37 24	.....	.....	.....	.....	
		L.....	12 40 42	.....	.....	.....	.....	
		iL.....	12 43 36	.....	.....	.....	.....	
		M.....	12 45 36	.....	*1,200	.....	.....	
		eL.....	12 48 48	.....	.....	.....	.....	
		eL.....	13 36 12	.....	.....	.....	.....	
		F.....	14 34 12?	.....	.....	.....	.....	
4	.....	L.....	9 18 48?	.....	*50	.....	.....	
9	.....	P.....	3 28 42	.....	.....	.....	11,920	P waves very minute; S fairly large.
		PR.....	3 35 06	.....	.....	.....	.....	
		iS.....	3 41 00	.....	.....	.....	.....	
		iS.....	3 46 48	.....	.....	.....	.....	
		L?.....	3 59 36	.....	.....	.....	.....	
		eL.....	4 10 42	.....	.....	.....	.....	
		eL.....	4 14 36	.....	.....	.....	.....	
		M.....	4 16 36	.....	*700	.....	.....	
		eL.....	4 25 30	.....	.....	.....	.....	
		eL.....	5 26 00	.....	.....	.....	.....	
		F.....	5 39 00	.....	.....	.....	.....	
16	.....	eL.....	8 47 36	.....	*100	.....	.....	Gradual thickening.
		F.....	9 20 48	.....	.....	.....	.....	
17	.....	L.....	8 31 48	.....	*50	.....	.....	
		F.....	8 37 06	.....	.....	.....	.....	
19	.....	eL.....	2 42 54	.....	.....	.....	.....	Gradual thickening. May not be seismic.
		M.....	2 44 24	.....	*300	.....	.....	
		F.....	2 55 24	.....	.....	.....	.....	
21	.....	eL.....	17 00 30	.....	.....	.....	.....	Merged into next quake.
		eL.....	17 03 00	.....	.....	.....	.....	
		M.....	17 13 18	.....	*900	.....	.....	
		eL.....	17 22 06	.....	.....	.....	.....	
21	.....	eL.....	18 37 48	.....	.....	.....	.....	Dual earthquake.
		M.....	18 44 06	.....	*200	.....	.....	
		F.....	19 02 42	.....	.....	.....	.....	
26	.....	L.....	10 50 24	.....	*100	.....	.....	
		F.....	10 54 24	.....	.....	.....	.....	

* Trace amplitude.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Canada. *Victoria, B. C. Dominion Meteorological Service.*								
Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.								
Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian.								
Instrumental constant.. T_0 18. Pillar deviation, 1 mm., swing of boom=0.54″.								
1919. Mar. 2	.....	P.....	*H. m. s.* 3 50 46	*Sec.*	.....	.....	*km.* 6,290	Vertical: M at 4h 17m 20s with μ=1.
		S.....	3 58 38	.....	.....	.....	.....	
		L.....	4 10 27	.....	.....	.....	.....	
		eL.....	4 17 13	.....	.....	.....	.....	
		M.....	4 21 46	.....	*800	.....	.....	
		F.....	6 18 19	.....	.....	.....	.....	
2	.....	P.....	12 09 00	.....	.....	.....	5,730	Vertical: M at 12h 40m 30s with a period of 16s and μ=3.
		S.....	12 16 22	.....	.....	.....	.....	
		L.....	12 26 46	.....	.....	.....	.....	
		M.....	12 40 28	.....	*200	.....	.....	
		F.....	14 22 16	.....	.....	.....	.....	
4	.....	P.....	9 03 45?	.....	.....	.....	.....	
		M.....	9 12 36	.....	*200	.....	.....	
		F.....	9 27 41	.....	.....	.....	.....	
9	.....	P.....	3 50 34	.....	.....	.....	4,720	
		S.....	3 57 01	.....	.....	.....	.....	
		L.....	4 04 28	.....	.....	.....	.....	
		M.....	4 12 53	.....	*500	.....	.....	
		F.....	5 59 00s	.....	.....	.....	.....	Clock stopped from 17h of the 15th to early morning of the 17th.
21	.....	P.....	16 24 39	.....	.....	.....	5,190	
		S.....	16 31 32	.....	.....	.....	.....	
		L.....	16 42 50	.....	.....	.....	.....	
		M.....	16 54 09	.....	*2,500	.....	.....	
		F.....	17 13 50	.....	.....	.....	.....	
			VERTICAL.		A_E			
		L.....	*16 44 00*	*20*	.....	.....	.....	
		M.....	*16 48 55*	*20*	*4*	.....	.....	
21	.....	P.....	18 04 59	.....	.....	.....	4,640	
		S.....	18 11 22	.....	.....	.....	.....	
	.....	L.....	18 21 12	.....	.....	.....	.....	
		M.....	18 35 28	.....	*200	.....	.....	
		F.....	18 47 16	.....	.....	.....	.....	
22	.....	L.....	17 02 37	.....	.....	.....	.....	
		M.....	17 08 31	.....	*300	.....	.....	
		F.....	17 22 47	.....	.....	.....	.....	

*Trace amplitude.

TABLE 3.—*Late reports (Instrumental).*

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

Instrumental constants.. {E V 13, T_0 22, ϵ 4:1; N V 14, T_0 25, ϵ 4:1}

1919. Feb. 2	.....	eL.....	*H. m. s.* 20 25 33	*Sec.* 15	.....	.....	*km.*	In addition to the quake of Feb. 1 given in the February Review.
		F.....	20 36 ..	.....	.....	.....	.....	
15	.....	eL.....	2 41 30	16	.....	.....	.....	
		F.....	2 46 ..	.....	.....	.....	.....	

SEISMOLOGICAL DISPATCHES.[1]

No dispatches for March, 1919.

[1] Reported by the organization indicated and collected by the seismological department of Georgetown University, Washington, D. C.

Chart I. Hydrographs of Several Principal Rivers, March, 1919.

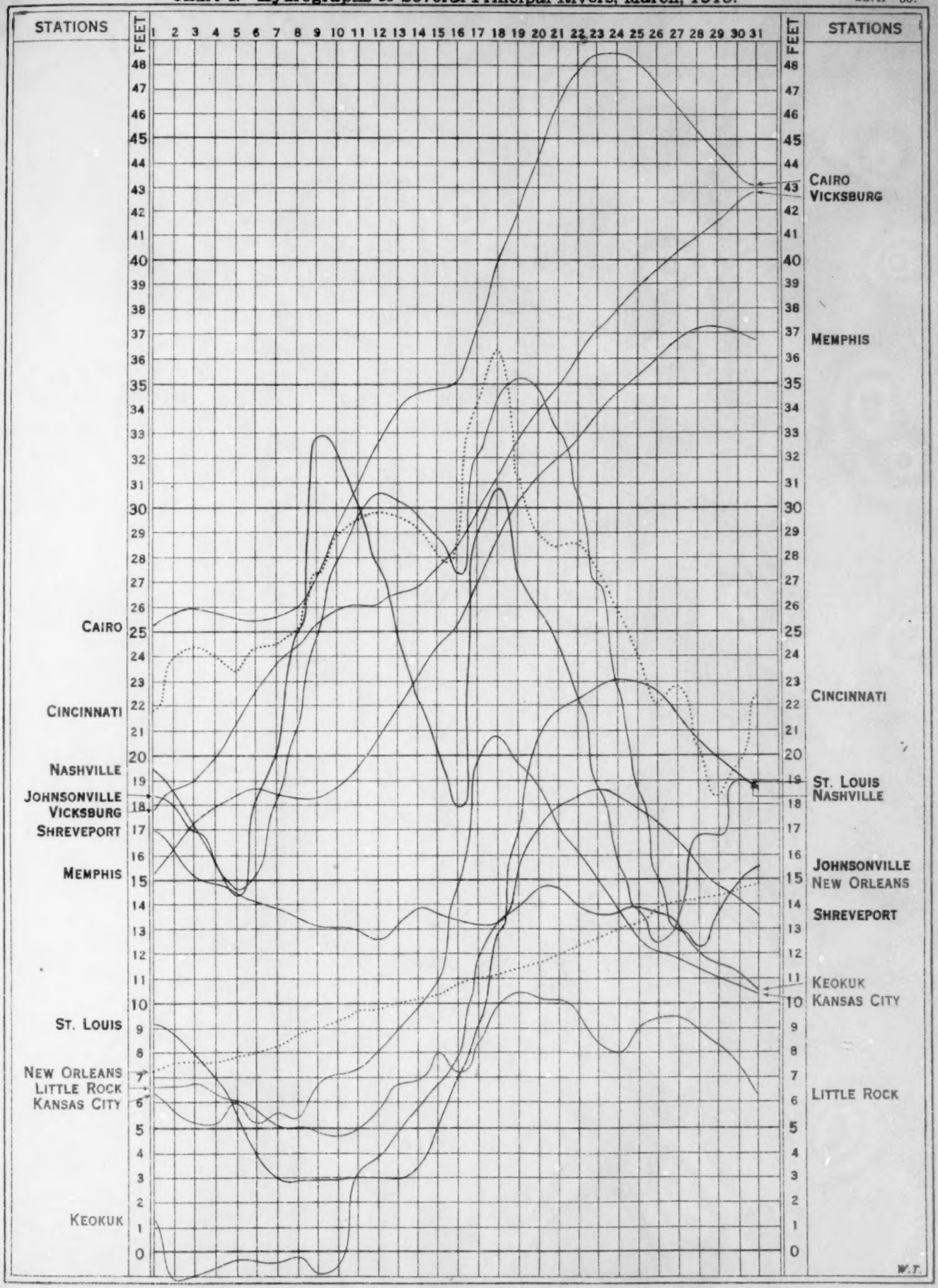


Chart II. Tracks of Centers of High Areas, March, 1919.

(Plotted by R. H. Weightman, Meteorologist.)

Chart III. Tracks of Centers of Low Areas, March, 1919.

(Plotted by R. H. Weightman, Meteorologist.)

Chart III. Tracks of Centers of Low Areas, March, 1919.

(Plotted by R. H. Weightman, Meteorologist.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, March, 1919.

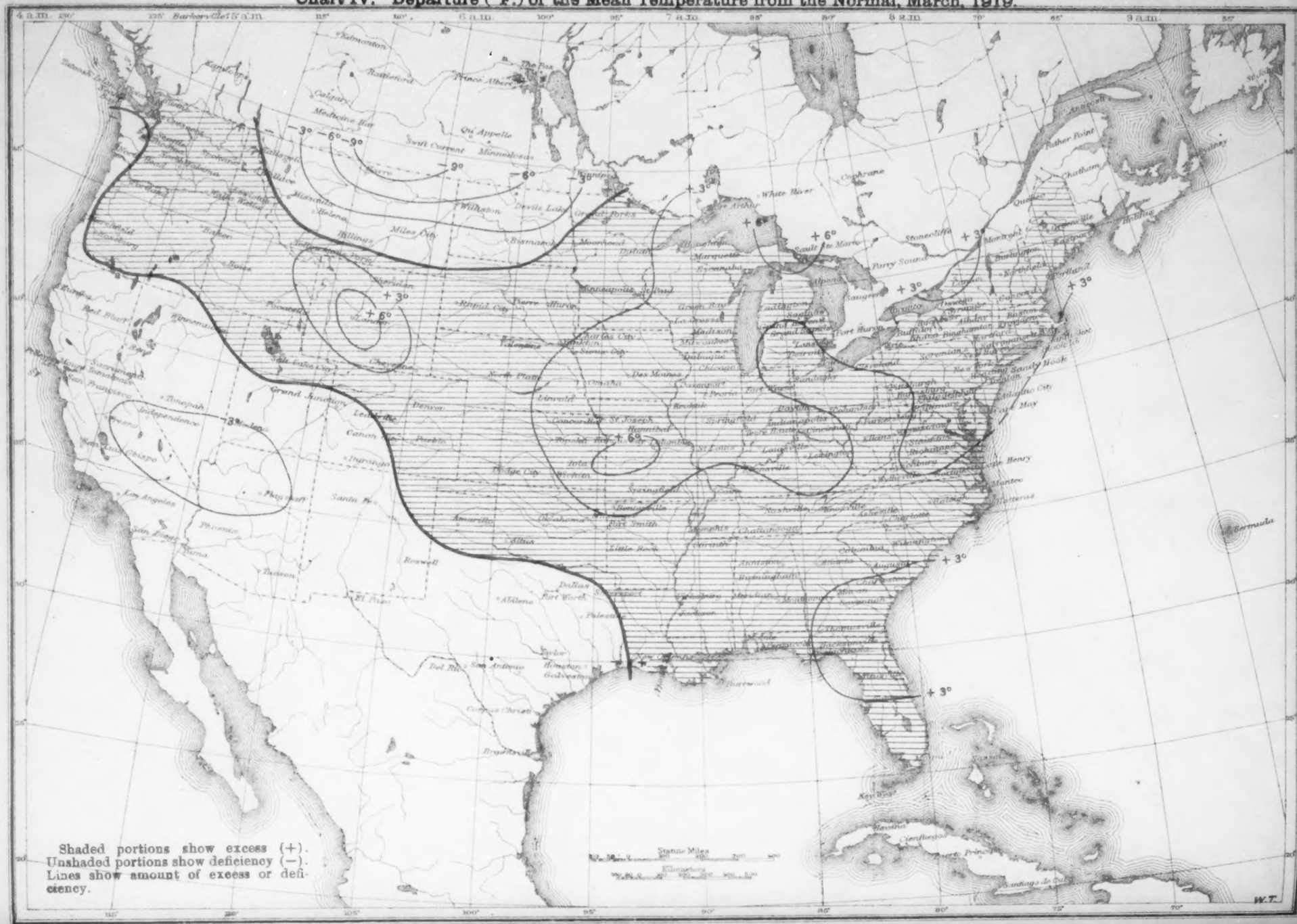


Chart V. Total Precipitation, Inches, March, 1919.

Chart V. Total Precipitation, Inches, March, 1919.

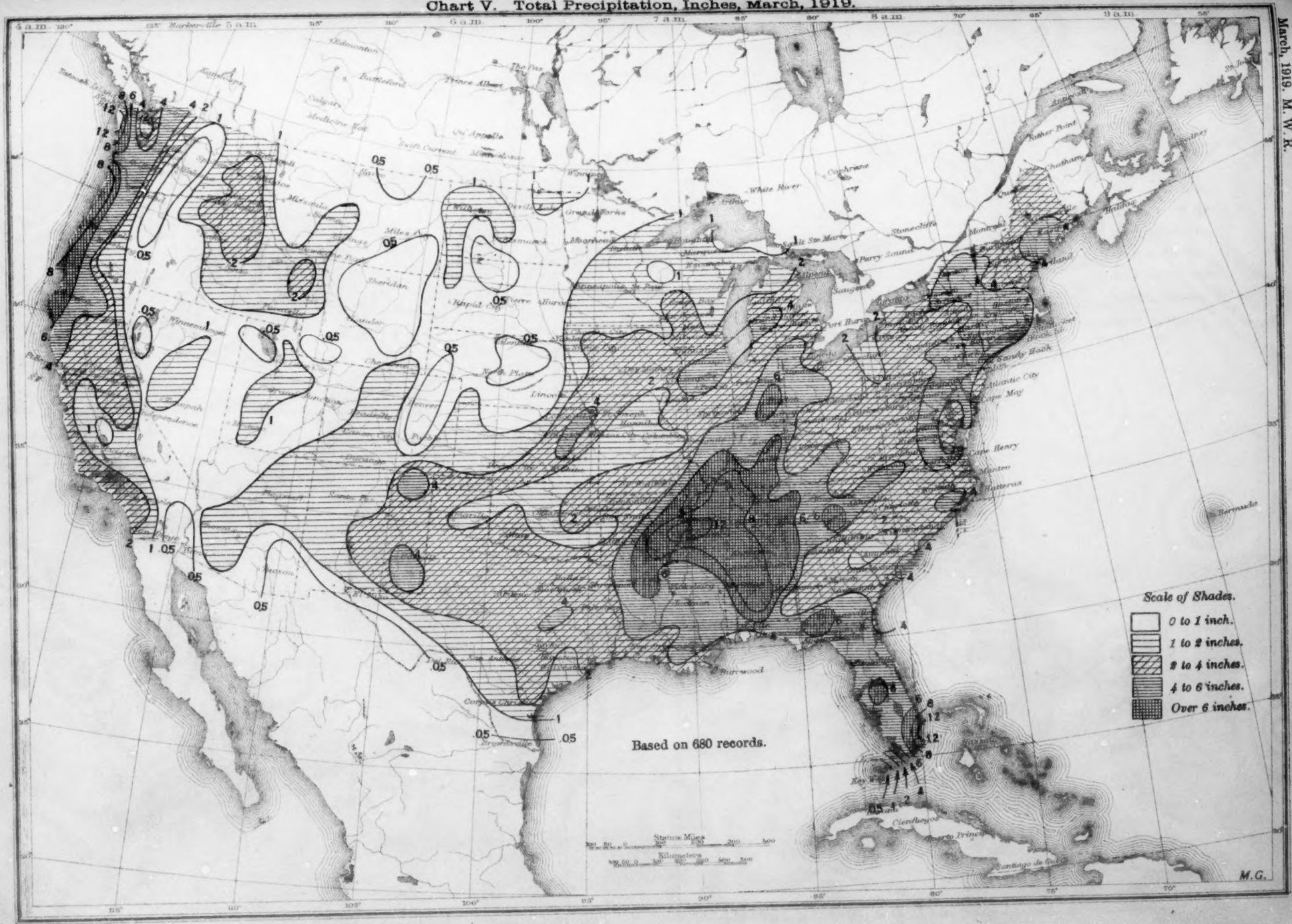


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, March, 1919.

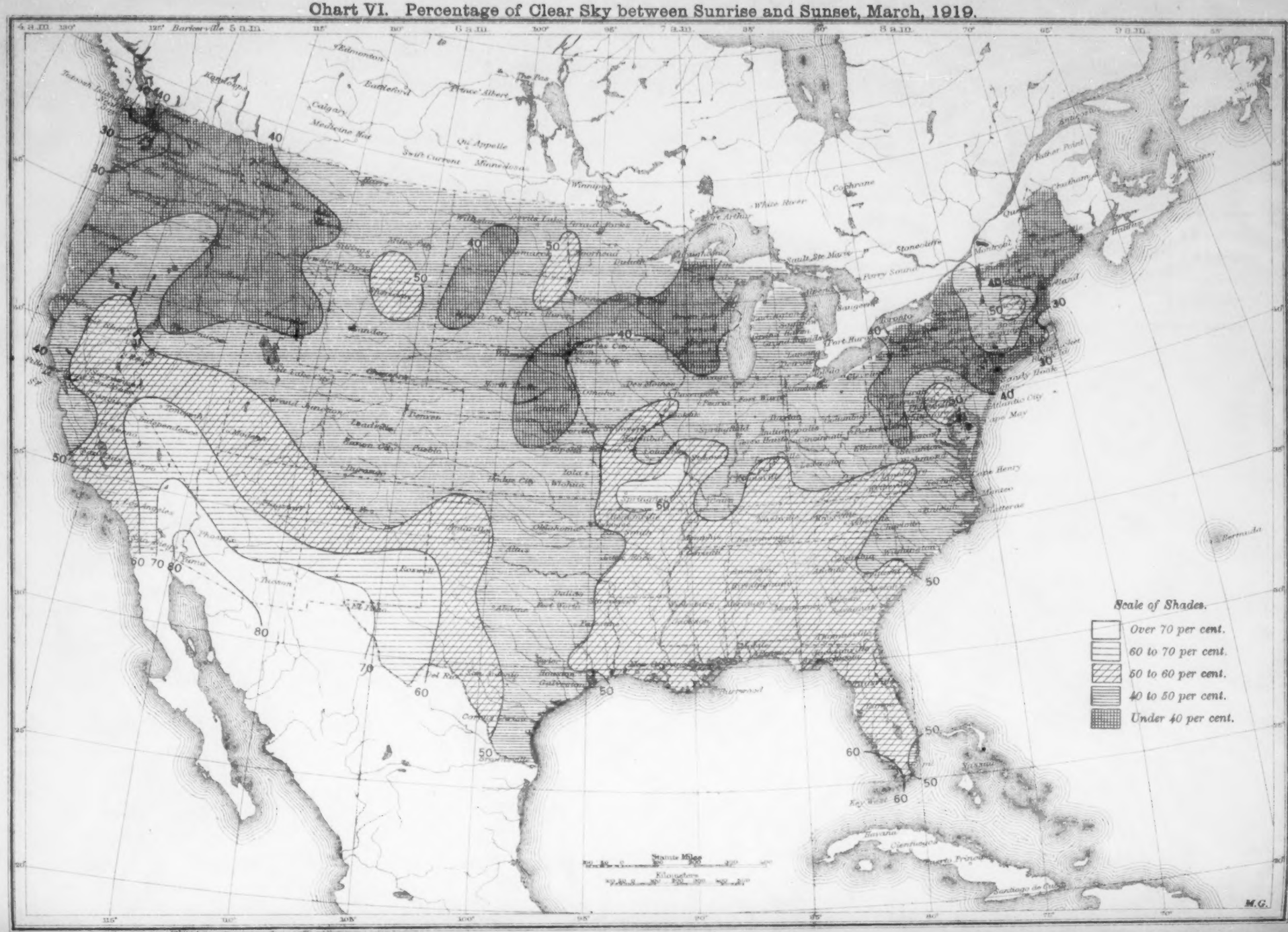
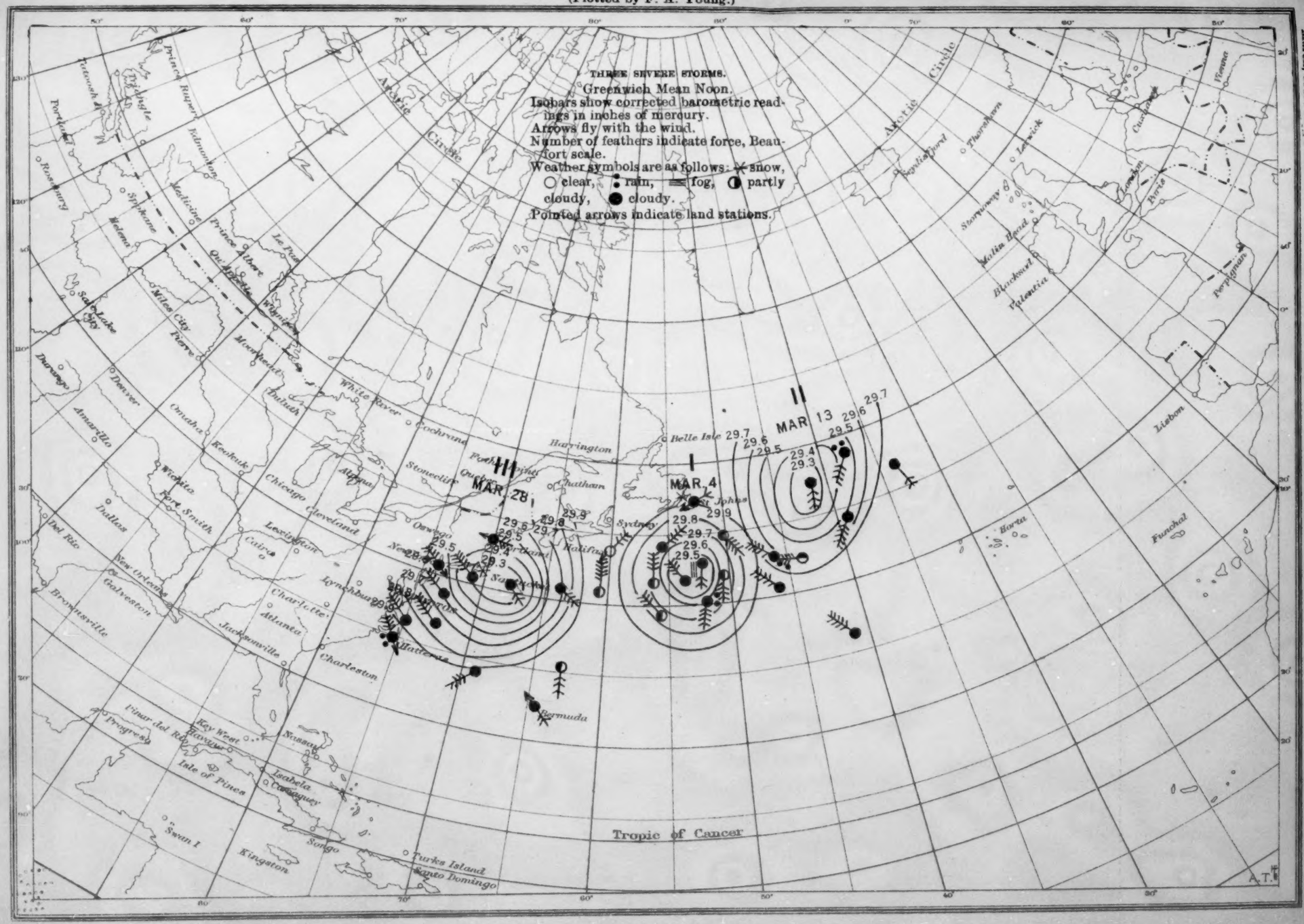


Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, March, 1919.

Chart VIII. Total Snowfall, Inches, March, 1919.

Chart IX. Meteorological Data for North Atlantic Ocean, March, 1919.

(Plotted by E. A. Kearney.)

Chart IX. Meteorological Data for North Atlantic Ocean, March, 1919.

(Plotted by F. A. Young.)